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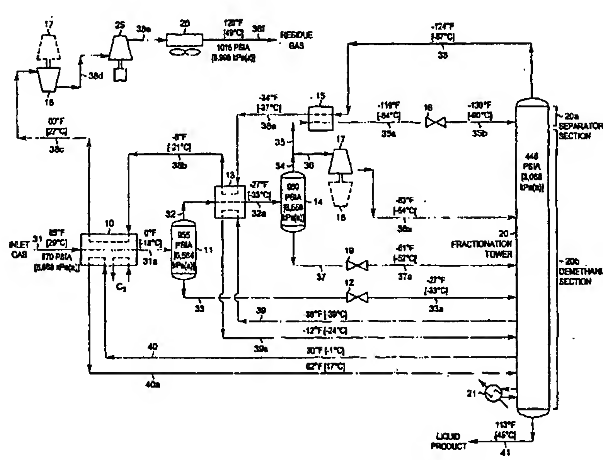
(54) Title: HYDROCARBON GAS PROCESSING



(57) Abstract: A process for the recovery of ethane, ethylene, propane, propylene, and heavier hydrocarbon components from a hydrocarbon gas stream is disclosed. The stream is cooled and divided into first and second streams. The first stream is further cooled to condense substantially all of it and is thereafter expanded to the fractionation tower pressure and supplied to the fractionation tower at a first mid-column feed position. The second stream is expanded to the tower pressure and is then supplied to the column at a second mid-column feed position. A distillation stream is withdrawn from the column below the feed point of the second stream and is then directed into heat exchange relation with the tower overhead vapor stream to cool the distillation stream and condense at least a part of it, forming a condensed stream. At least a portion of the condensed stream is directed to the fractionation tower as its top feed. The quantities and temperatures of the feeds to the fractionation tower are effective to maintain the overhead temperature of the fractionation tower at a temperature whereby the major portion of the desired components is recovered.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

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TO ALL WHOM IT MAY CONCERN:

Be it known that WE, KYLE T. CUELLAR, a citizen of the United States, residing in Katy, County of Fort Bend, State of Texas, whose post office address is 1611 Cottage Point, Katy, Texas 77494, and JOHN D. WILKINSON, JOE T. LYNCH, and HANK M. HUDSON, all citizens of the United States, all residing in Midland, County of Midland, State of Texas, whose post office addresses are 2800 W. Dengar, Midland, Texas 79705; 5510 Ashwood Ct., Midland, Texas 79707; and 2508 W. Sinclair, Midland, Texas 79705, respectively, have invented an improvement in

HYDROCARBON GAS PROCESSING

of which the following is a

SPECIFICATION

BACKGROUND OF THE INVENTION

[0001] This invention relates to a process for the separation of a gas containing hydrocarbons. The applicants claim the benefits under Title 35, United States Code, Section 119(e) of prior U.S. Provisional Application Number 60/449,772 which was filed on February 25, 2003.

[0002] Ethylene, ethane, propylene, propane and/or heavier hydrocarbons can be recovered from a variety of gases, such as natural gas, refinery gas, and synthetic gas streams obtained from other hydrocarbon materials such as coal, crude oil, naphtha, oil shale, tar sands, and lignite. Natural gas usually has a major proportion of methane and ethane, i.e., methane and ethane together comprise at least 50 mole percent of the gas.

The gas also contains relatively lesser amounts of heavier hydrocarbons such as propane, butanes, pentanes and the like, as well as hydrogen, nitrogen, carbon dioxide and other gases.

[0003] The present invention is generally concerned with the recovery of ethylene, ethane, propylene, propane and heavier hydrocarbons from such gas streams. A typical analysis of a gas stream to be processed in accordance with this invention would be, in approximate mole percent, 80.8% methane, 9.4% ethane and other C_2 components, 4.7% propane and other C_3 components, 1.2% iso-butane, 2.1% normal butane, and 1.1% pentanes plus, with the balance made up of nitrogen and carbon dioxide. Sulfur containing gases are also sometimes present.

[0004] The historically cyclic fluctuations in the prices of both natural gas and its natural gas liquid (NGL) constituents have at times reduced the incremental value of ethane, ethylene, propane, propylene, and heavier components as liquid products. This has resulted in a demand for processes that can provide more efficient recoveries of these products, for processes that can provide efficient recoveries with lower capital investment, and for processes that can be easily adapted or adjusted to vary the recovery of a specific component over a broad range. Available processes for separating these materials include those based upon cooling and refrigeration of gas, oil absorption, and refrigerated oil absorption. Additionally, cryogenic processes have become popular because of the availability of economical equipment that produces power while simultaneously expanding and extracting heat from the gas being processed. Depending upon the pressure of the gas source, the richness (ethane, ethylene, and heavier

hydrocarbons content) of the gas, and the desired end products, each of these processes or a combination thereof may be employed.

[0005] The cryogenic expansion process is now generally preferred for natural gas liquids recovery because it provides maximum simplicity with ease of startup, operating flexibility, good efficiency, safety, and good reliability. U.S. Pat. Nos. 3,292,380; 4,061,481; 4,140,504; 4,157,904; 4,171,964; 4,185,978; 4,251,249; 4,278,457; 4,519,824; 4,617,039; 4,687,499; 4,689,063; 4,690,702; 4,854,955; 4,869,740; 4,889,545; 5,275,005; 5,555,748; 5,568,737; 5,771,712; 5,799,507; 5,881,569; 5,890,378; 5,983,664; 6,182,469; reissue U.S. Pat. No. 33,408; and co-pending application no. 09/677,220 describe relevant processes (although the description of the present invention in some cases is based on different processing conditions than those described in the cited U.S. Patents).

[0006] In a typical cryogenic expansion recovery process, a feed gas stream under pressure is cooled by heat exchange with other streams of the process and/or external sources of refrigeration such as a propane compression-refrigeration system. As the gas is cooled, liquids may be condensed and collected in one or more separators as high-pressure liquids containing some of the desired C_2+ components. Depending on the richness of the gas and the amount of liquids formed, the high-pressure liquids may be expanded to a lower pressure and fractionated. The vaporization occurring during expansion of the liquids results in further cooling of the stream. Under some conditions, pre-cooling the high pressure liquids prior to the expansion may be desirable in order to further lower the temperature resulting from the expansion. The expanded stream,

comprising a mixture of liquid and vapor, is fractionated in a distillation (demethanizer or deethanizer) column. In the column, the expansion cooled stream(s) is (are) distilled to separate residual methane, nitrogen, and other volatile gases as overhead vapor from the desired C_2 components, C_3 components, and heavier hydrocarbon components as bottom liquid product, or to separate residual methane, C_2 components, nitrogen, and other volatile gases as overhead vapor from the desired C_3 components and heavier hydrocarbon components as bottom liquid product.

[0007] If the feed gas is not totally condensed (typically it is not), the vapor remaining from the partial condensation can be split into two streams. One portion of the vapor is passed through a work expansion machine or engine, or an expansion valve, to a lower pressure at which additional liquids are condensed as a result of further cooling of the stream. The pressure after expansion is essentially the same as the pressure at which the distillation column is operated. The combined vapor-liquid phases resulting from the expansion are supplied as feed to the column.

[0008] The remaining portion of the vapor is cooled to substantial condensation by heat exchange with other process streams, e.g., the cold fractionation tower overhead. Some or all of the high-pressure liquid may be combined with this vapor portion prior to cooling. The resulting cooled stream is then expanded through an appropriate expansion device, such as an expansion valve, to the pressure at which the demethanizer is operated. During expansion, a portion of the liquid will vaporize, resulting in cooling of the total stream. The flash expanded stream is then supplied as top feed to the demethanizer. Typically, the vapor portion of the expanded stream and the demethanizer overhead

vapor combine in an upper separator section in the fractionation tower as residual methane product gas. Alternatively, the cooled and expanded stream may be supplied to a separator to provide vapor and liquid streams. The vapor is combined with the tower overhead and the liquid is supplied to the column as a top column feed.

[0009] In the ideal operation of such a separation process, the residue gas leaving the process will contain substantially all of the methane in the feed gas with essentially none of the heavier hydrocarbon components and the bottoms fraction leaving the demethanizer will contain substantially all of the heavier hydrocarbon components with essentially no methane or more volatile components. In practice, however, this ideal situation is not obtained because the conventional demethanizer is operated largely as a stripping column. The methane product of the process, therefore, typically comprises vapors leaving the top fractionation stage of the column, together with vapors not subjected to any rectification step. Considerable losses of C_3 and C_4+ components occur because the top liquid feed contains substantial quantities of these components and heavier hydrocarbon components, resulting in corresponding equilibrium quantities of C_3 components, C_4 components, and heavier hydrocarbon components in the vapors leaving the top fractionation stage of the demethanizer. The loss of these desirable components could be significantly reduced if the rising vapors could be brought into contact with a significant quantity of liquid (reflux) capable of absorbing the C_3,components, C_4 components, and heavier hydrocarbon components from the vapors.

[0010] In recent years, the preferred processes for hydrocarbon separation use an upper absorber section to provide additional rectification of the rising vapors. The source

of the reflux stream for the upper rectification section is typically a recycled stream of residue gas supplied under pressure. The recycled residue gas stream is usually cooled to substantial condensation by heat exchange with other process streams, e.g., the cold fractionation tower overhead. The resulting substantially condensed stream is then expanded through an appropriate expansion device, such as an expansion valve, to the pressure at which the demethanizer is operated. During expansion, a portion of the liquid will usually vaporize, resulting in cooling of the total stream. The flash expanded stream is then supplied as top feed to the demethanizer. Typically, the vapor portion of the expanded stream and the demethanizer overhead vapor combine in an upper separator section in the fractionation tower as residual methane product gas. Alternatively, the cooled and expanded stream may be supplied to a separator to provide vapor and liquid streams, so that thereafter the vapor is combined with the tower overhead and the liquid is supplied to the column as a top column feed. Typical process schemes of this type are disclosed in U.S. Patent Nos. 4,889,545; 5,568,737; and 5,881,569, and in Mowrey, E. Ross, "Efficient, High Recovery of Liquids from Natural Gas Utilizing a High Pressure Absorber", Proceedings of the Eighty-First Annual Convention of the Gas Processors Association, Dallas, Texas, March 11-13, 2002. Unfortunately, these processes require the use of a compressor to provide the motive force for recycling the reflux stream to the demethanizer, adding to both the capital cost and the operating cost of facilities using these processes.

[0011] The present invention also employs an upper rectification section (or a separate rectification column in some embodiments). However, the reflux stream for this

rectification section is provided by using a side draw of the vapors rising in a lower portion of the tower. Because of the relatively high concentration of C_2 components in the vapors lower in the tower, a significant quantity of liquid can be condensed in this side draw stream without elevating its pressure, often using only the refrigeration available in the cold vapor leaving the upper rectification section. This condensed liquid, which is predominantly liquid methane and ethane, can then be used to absorb C_3 components, C_4 components, and heavier hydrocarbon components from the vapors rising through the upper rectification section and thereby capture these valuable components in the bottom liquid product from the demethanizer.

[0012] Heretofore, such a side draw feature has been employed in C_3+ recovery systems, as illustrated in the assignee's U.S. Patent No. 5,799,507. The process and apparatus of U.S. Patent No. 5,799,507, however, is unsuitable for high ethane recovery. Surprisingly, applicants have found that by combining the side draw feature of the assignee's U.S. Patent No. 5,799,507 invention with the split vapor feed invention of the assignee's U.S. Patent No. 4,278,457, C_3+ recoveries may be improved without sacrificing C_2 component recovery levels or system efficiency.

[0013] In accordance with the present invention, it has been found that C_3 and C_4+ recoveries in excess of 99 percent can be obtained without the need for compression of the reflux stream for the demethanizer with no loss in C_2 component recovery. The present invention provides the further advantage of being able to maintain in excess of 99 percent recovery of the C_3 and C_4+ components as the recovery of C_2 components is adjusted from high to low values. In addition, the present invention makes possible

essentially 100 percent separation of methane and lighter components from the C_2 components and heavier components at reduced energy requirements compared to the prior art while maintaining the same recovery levels. The present invention, although applicable at lower pressures and warmer temperatures, is particularly advantageous when processing feed gases in the range of 400 to 1500 psia [2,758 to 10,342 kPa(a)] or higher under conditions requiring NGL recovery column overhead temperatures of -50°F [-46°C] or colder.

[0014] For a better understanding of the present invention, reference is made to the following examples and drawings. Referring to the drawings:

[0015] FIGS. 1 and 2 are flow diagrams of prior art natural gas processing plants in accordance with United States Patent No. 4,278,457;

[0016] FIGS. 3 and 4 are flow diagrams of natural gas processing plants in accordance with the present invention;

[0017] FIG. 5 is a flow diagram illustrating an alternative means of application of the present invention to a natural gas stream;

[0018] FIG. 6 is a flow diagram illustrating an alternative means of application of the present invention to a natural gas stream; and

[0019] FIG. 7 is a flow diagram illustrating an alternative means of application of the present invention to a natural gas stream.

[0020] In the following explanation of the above figures, tables are provided summarizing flow rates calculated for representative process conditions. In the tables appearing herein, the values for flow rates (in moles per hour) have been rounded to the

nearest whole number for convenience. The total stream rates shown in the tables include all non-hydrocarbon components and hence are generally larger than the sum of the stream flow rates for the hydrocarbon components. Temperatures indicated are approximate values rounded to the nearest degree. It should also be noted that the process design calculations performed for the purpose of comparing the processes depicted in the figures are based on the assumption of no heat leak from (or to) the surroundings to (or from) the process. The quality of commercially available insulating materials makes this a very reasonable assumption and one that is typically made by those skilled in the art.

[0021] For convenience, process parameters are reported in both the traditional British units and in the units of the Système International d'Unités (SI). The molar flow rates given in the tables may be interpreted as either pound moles per hour or kilogram moles per hour. The energy consumptions reported as horsepower (HP) and/or thousand British Thermal Units per hour (MBTU/Hr) correspond to the stated molar flow rates in pound moles per hour. The energy consumptions reported as kilowatts (kW) correspond to the stated molar flow rates in kilogram moles per hour.

DESCRIPTION OF THE PRIOR ART

[0022] FIG. 1 is a process flow diagram showing the design of a processing plant to recover C_2+ components from natural gas using prior art according to U.S. Pat. No. 4,278,457. In this simulation of the process, inlet gas enters the plant at 85°F [29°C] and 970 psia [6,688 kPa(a)] as stream **31**. If the inlet gas contains a concentration of sulfur compounds which would prevent the product streams from meeting specifications, the

sulfur compounds are removed by appropriate pretreatment of the feed gas (not illustrated). In addition, the feed stream is usually dehydrated to prevent hydrate (ice) formation under cryogenic conditions. Solid desiccant has typically been used for this purpose.

[0023] The feed stream **31** is cooled in heat exchanger **10** by heat exchange with cool residue gas at -6°F [-21°C] (stream **38b**), demethanizer lower side reboiler liquids at 30°F [-1°C] (stream **40**), and propane refrigerant. Note that in all cases exchanger **10** is representative of either a multitude of individual heat exchangers or a single multi-pass heat exchanger, or any combination thereof. (The decision as to whether to use more than one heat exchanger for the indicated cooling services will depend on a number of factors including, but not limited to, inlet gas flow rate, heat exchanger size, stream temperatures, etc.) The cooled stream **31a** enters separator **11** at 0°F [–18°C] and 955 psia [6,584 kPa(a)] where the vapor (stream **32**) is separated from the condensed liquid (stream **33**). The separator liquid (stream **33**) is expanded to the operating pressure (approximately 445 psia [3,068 kPa(a)]) of fractionation tower **20** by expansion valve **12**, cooling stream **33a** to -27°F [-33°C] before it is supplied to fractionation tower **20** at a lower mid-column feed point.

[0024] The separator vapor (stream **32**) is further cooled in heat exchanger **13** by heat exchange with cool residue gas at -34°F [-37°C] (stream **38a**) and demethanizer upper side reboiler liquids at -38°F [-39°C] (stream **39**). The cooled stream **32a** enters separator **14** at -27°F [–33°C] and 950 psia [6,550 kPa(a)] where the vapor (stream **34**) is separated from the condensed liquid (stream **37**). The separator liquid (stream **37**) is

expanded to the tower operating pressure by expansion valve **19**, cooling stream **37a** to -61°F [-52°C] before it is supplied to fractionation tower **20** at a second lower mid-column feed point.

[0025] The vapor (stream **34**) from separator **14** is divided into two streams, **35** and **36**. Stream **35**, containing about 38% of the total vapor, passes through heat exchanger **15** in heat exchange relation with the cold residue gas at -124°F [-87°C] (stream **38**) where it is cooled to substantial condensation. The resulting substantially condensed stream **35a** at -119°F [-84°C] is then flash expanded through expansion valve **16** to the operating pressure of fractionation tower **20**. During expansion a portion of the stream is vaporized, resulting in cooling of the total stream. In the process illustrated in FIG. 1, the expanded stream **35b** leaving expansion valve **16** reaches a temperature of -130°F [-90°C] and is supplied to separator section **20a** in the upper region of fractionation tower **20**. The liquids separated therein become the top feed to demethanizing section **20b**.

[0026] The remaining 62% of the vapor from separator **14** (stream **36**) enters a work expansion machine **17** in which mechanical energy is extracted from this portion of the high pressure feed. The machine **17** expands the vapor substantially isentropically to the tower operating pressure, with the work expansion cooling the expanded stream **36a** to a temperature of approximately -83°F [-64°C]. The typical commercially available expanders are capable of recovering on the order of 80-85% of the work theoretically available in an ideal isentropic expansion. The work recovered is often used to drive a centrifugal compressor (such as item **18**) that can be used to re-compress the residue gas

(stream **38c**), for example. The partially condensed expanded stream **36a** is thereafter supplied as feed to fractionation tower **20** at an upper mid-column feed point.

[0027] The demethanizer in tower **20** is a conventional distillation column containing a plurality of vertically spaced trays, one or more packed beds, or some combination of trays and packing. As is often the case in natural gas processing plants, the fractionation tower may consist of two sections. The upper section **20a** is a separator wherein the partially vaporized top feed is divided into its respective vapor and liquid portions, and wherein the vapor rising from the lower distillation or demethanizing section **20b** is combined with the vapor portion of the top feed to form the cold demethanizer overhead vapor (stream **38**) which exits the top of the tower at -124°F [-87°C]. The lower, demethanizing section **20b** contains the trays and/or packing and provides the necessary contact between the liquids falling downward and the vapors rising upward. The demethanizing section **20b** also includes reboilers (such as reboiler **21** and the side reboilers described previously) which heat and vaporize a portion of the liquids flowing down the column to provide the stripping vapors which flow up the column to strip the liquid product, stream **41**, of methane and lighter components.

[0028] The liquid product stream **41** exits the bottom of the tower at 113°F [45°C], based on a typical specification of a methane to ethane ratio of 0.025:1 on a molar basis in the bottom product. The residue gas (demethanizer overhead vapor stream **38**) passes countercurrently to the incoming feed gas in heat exchanger **15** where it is heated to -34°F [-37°C] (stream **38a**), in heat exchanger **13** where it is heated to -6°F [-21°C] (stream **38b**), and in heat exchanger **10** where it is heated to 80°F [27°C] (stream

38c). The residue gas is then re-compressed in two stages. The first stage is compressor 18 driven by expansion machine 17. The second stage is compressor 25 driven by a supplemental power source which compresses the residue gas (stream 38d) to sales line pressure. After cooling to 120°F [49°C] in discharge cooler 26, the residue gas product (stream 38f) flows to the sales gas pipeline at 1015 psia [6,998 kPa(a)], sufficient to meet line requirements (usually on the order of the inlet pressure).

[0029] A summary of stream flow rates and energy consumption for the process illustrated in FIG. 1 is set forth in the following table:

Table I

(FIG. 1)

Stream Flow Summary - Lb. Moles/Hr [kg moles/Hr]

Stream	Methane	Ethane	Propane	Butanes+	Total
31	53,228	6,192	3,070	2,912	65,876
32	49,244	4,670	1,650	815	56,795
33	3,984	1,522	1,420	2,097	9,081
34	47,675	4,148	1,246	445	53,908
37	1,569	522	404	370	2,887
35	18,117	1,576	473	169	20,485
36	29,558	2,572	773	276	33,423
38	53,098	978	44	4	54,460
41	130	5,214	3,026	2,908	11,416

Recoveries*

Ethane	84.21%				
Propane	98.58%				
Butanes+	99.88%				

Power

Residue Gas Compression	23,628	HP	[	38,844	kW]

Utility Cooling

Propane Refrigeration Duty	37,455	MBTU/H	[	24,194	kW]

* (Based on un-rounded flow rates)

[0030] FIG. 2 is a process flow diagram showing one manner in which the design of the processing plant in FIG. 1 can be adapted to operate at a lower C_2 component recovery level. This is a common requirement when the C_2 components recovered in the processing plant are dedicated to a downstream chemical plant that has a limited capacity. The process of FIG. 2 has been applied to the same feed gas composition and conditions as described previously for FIG. 1. However, in the simulation of the process of FIG. 2 the process operating conditions have been adjusted to reduce the recovery of C_2 components to about 50%.

[0031] In the simulation of the FIG. 2 process, the inlet gas cooling, separation, and expansion scheme for the processing plant is much the same as that used in FIG. 1. The main difference is that the flash expanded separator liquid streams (streams **33a** and **37a**) are used to provide feed gas cooling, instead of using side reboiler liquids from fractionation tower **20** as shown in FIG. 1. Due to the lower recovery of C_2 components

in the tower bottom liquid (stream **41**), the temperatures in fractionation tower **20** are higher, making the tower liquids too warm for effective heat exchange with the feed gas.

[0032] The feed stream **31** is cooled in heat exchanger **10** by heat exchange with cool residue gas at -7°F [-21°C] (stream **38b**), flash expanded liquids (stream **33a**), and propane refrigerant. The cooled stream **31a** enters separator **11** at 0°F [–18°C] and 955 psia [6,584 kPa(a)] where the vapor (stream **32**) is separated from the condensed liquid (stream **33**). The separator liquid (stream **33**) is expanded to slightly above the operating pressure (approximately 444 psia [3,061 kPa(a)]) of fractionation tower **20** by expansion valve **12**, cooling stream **33a** to -27°F [-33°C] before it enters heat exchanger **10** and is heated as it provides cooling of the incoming feed gas as described earlier. The expanded liquid stream is heated to 75°F [24°C], partially vaporizing stream **33b** before it is supplied to fractionation tower **20** at a lower mid-column feed point.

[0033] The separator vapor (stream **32**) is further cooled in heat exchanger **13** by heat exchange with cool residue gas at -30°F [-34°C] (stream **38a**) and flash expanded liquids (stream **37a**). The cooled stream **32a** enters separator **14** at -14°F [–25°C] and 950 psia [6,550 kPa(a)] where the vapor (stream **34**) is separated from the condensed liquid (stream **37**). The separator liquid (stream **37**) is expanded to slightly above the operating pressure of fractionation tower **20** by expansion valve **19**, cooling stream **37a** to -44°F [-42°C] before it enters heat exchanger **13** and is heated as it provides cooling of stream **32** as described earlier. The expanded liquid stream is heated to -5°F [-21°C], partially vaporizing stream **37b** before it is supplied to fractionation tower **20** at a second lower mid-column feed point.

[0034] The vapor (stream **34**) from separator **14** is divided into two streams, **35** and **36**. Stream **35**, containing about 32% of the total vapor, passes through heat exchanger **15** in heat exchange relation with the cold residue gas at -101°F [-74°C] (stream **38**) where it is cooled to substantial condensation. The resulting substantially condensed stream **35a** at -96°F [-71°C] is then flash expanded through expansion valve **16** to the operating pressure of fractionation tower **20**. During expansion a portion of the stream is vaporized, resulting in cooling of the total stream. In the process illustrated in FIG. 2, the expanded stream **35b** leaving expansion valve **16** reaches a temperature of -127°F [-88°C] and is supplied to fractionation tower **20** as the top feed.

[0035] The remaining 68% of the vapor from separator **14** (stream **36**) enters a work expansion machine **17** in which mechanical energy is extracted from this portion of the high pressure feed. The machine **17** expands the vapor substantially isentropically to the tower operating pressure, with the work expansion cooling the expanded stream **36a** to a temperature of approximately -70°F [-57°C]. The partially condensed expanded stream **36a** is thereafter supplied as feed to fractionation tower **20** an upper mid-column feed point.

[0036] The liquid product stream **41** exits the bottom of the tower at 140°F [60°C]. The residue gas (demethanizer overhead vapor stream **38**) passes countercurrently to the incoming feed gas in heat exchanger **15** where it is heated to -30°F [-34°C] (stream **38a**), in heat exchanger **13** where it is heated to -7°F [-21°C] (stream **38b**), and in heat exchanger **10** where it is heated to 80°F [27°C] (stream **38c**). The residue gas is then re-compressed in two stages, compressor **18** driven by expansion

machine **17** and compressor **25** driven by a supplemental power source. After stream **38e** is cooled to 120°F [49°C] in discharge cooler **26**, the residue gas product (stream **38f**) flows to the sales gas pipeline at 1015 psia [6,998 kPa(a)].

[0037] A summary of stream flow rates and energy consumption for the process illustrated in FIG. 2 is set forth in the following table:

Table II

(FIG. 2)

Stream Flow Summary - Lb. Moles/Hr [kg moles/Hr]

Stream	Methane	Ethane	Propane	Butanes+	Total
31	53,228	6,192	3,070	2,912	65,876
32	49,244	4,670	1,650	815	56,795
33	3,984	1,522	1,420	2,097	9,081
34	48,691	4,470	1,476	618	55,663
37	553	200	174	197	1,132
35	15,825	1,453	480	201	18,090
36	32,866	3,017	996	417	37,573
38	53,149	3,041	107	9	56,757
41	79	3,151	2,963	2,903	9,119

Recoveries*					
Ethane	50.89%				
Propane	96.51%				
Butanes+	99.68%				
Power					
Residue Gas Compression	23,773	HP	[	39,082	kW]
Utility Cooling					
Propane Refrigeration Duty	29,436	MBTU/H	[	19,014	kW]

* (Based on un-rounded flow rates)

DESCRIPTION OF THE INVENTION

Example 1

[0038] FIG. 3 illustrates a flow diagram of a process in accordance with the present invention. The feed gas composition and conditions considered in the process presented in FIG. 3 are the same as those in FIG. 1. Accordingly, the FIG. 3 process can be compared with that of the FIG. 1 process to illustrate the advantages of the present invention.

[0039] In the simulation of the FIG. 3 process, inlet gas enters the plant as stream **31** and is cooled in heat exchanger **10** by heat exchange with cool residue gas at -5°F [-20°C] (stream **45b**), demethanizer lower side reboiler liquids at 33°F [0°C] (stream **40**), and propane refrigerant. The cooled stream **31a** enters separator **11** at 0°F [–18°C] and 955 psia [6,584 kPa(a)] where the vapor (stream **32**) is separated from the condensed

liquid (stream **33**). The separator liquid (stream **33**) is expanded to the operating pressure (approximately 450 psia [3,103 kPa(a)]) of fractionation tower **20** by expansion valve **12**, cooling stream **33a** to -27°F [-33°C] before it is supplied to fractionation tower **20** at a lower mid-column feed point.

[0040] The separator vapor (stream **32**) is further cooled in heat exchanger **13** by heat exchange with cool residue gas at -36°F [-38°C] (stream **45a**) and demethanizer upper side reboiler liquids at -38°F [-39°C] (stream **39**). The cooled stream **32a** enters separator **14** at -29°F [–34°C] and 950 psia [6,550 kPa(a)] where the vapor (stream **34**) is separated from the condensed liquid (stream **37**). The separator liquid (stream **37**) is expanded to the tower operating pressure by expansion valve **19**, cooling stream **37a** to -64°F [-53°C] before it is supplied to fractionation tower **20** at a second lower mid-column feed point.

[0041] The vapor (stream **34**) from separator **14** is divided into two streams, **35** and **36**. Stream **35**, containing about 37% of the total vapor, passes through heat exchanger **15** in heat exchange relation with the cold residue gas at -120°F [-84°C] (stream **45**) where it is cooled to substantial condensation. The resulting substantially condensed stream **35a** at -115°F [-82°C] is then flash expanded through expansion valve **16** to the operating pressure of fractionation tower **20**. During expansion a portion of the stream is vaporized, resulting in cooling of the total stream. In the process illustrated in FIG. 3, the expanded stream **35b** leaving expansion valve **16** reaches a temperature of -129°F [-89°C] and is supplied to fractionation tower **20** at an upper mid-column feed point.

[0042] The remaining 63% of the vapor from separator **14** (stream **36**) enters a work expansion machine **17** in which mechanical energy is extracted from this portion of the high pressure feed. The machine **17** expands the vapor substantially isentropically to the tower operating pressure, with the work expansion cooling the expanded stream **36a** to a temperature of approximately -84°F [-65°C]. The partially condensed expanded stream **36a** is thereafter supplied as feed to fractionation tower **20** a lower mid-column feed point.

[0043] The demethanizer in tower **20** is a conventional distillation column containing a plurality of vertically spaced trays, one or more packed beds, or some combination of trays and packing. The demethanizer tower consists of two sections: an upper absorbing (rectification) section **20a** that contains the trays and/or packing to provide the necessary contact between the vapor portion of the expanded streams **35b** and **36a** rising upward and cold liquid falling downward to condense and absorb the ethane, propane, and heavier components; and a lower, stripping section **20b** that contains the trays and/or packing to provide the necessary contact between the liquids falling downward and the vapors rising upward. The demethanizing section **20b** also includes reboilers (such as reboiler **21** and the side reboilers described previously) which heat and vaporize a portion of the liquids flowing down the column to provide the stripping vapors which flow up the column to strip the liquid product, stream **41**, of methane and lighter components. Stream **36a** enters demethanizer **20** at an intermediate feed position located in the lower region of absorbing section **20a** of demethanizer **20**. The liquid portion of the expanded stream commingles with liquids falling downward from the absorbing

section **20a** and the combined liquid continues downward into the stripping section **20b** of demethanizer **20**. The vapor portion of the expanded stream rises upward through absorbing section **20a** and is contacted with cold liquid falling downward to condense and absorb the ethane, propane, and heavier components.

[0044] A portion of the distillation vapor (stream **42**) is withdrawn from the upper region of stripping section **20b**. This stream is then cooled from -91°F [-68°C] to -122°F [-86°C] and partially condensed (stream **42a**) in heat exchanger **22** by heat exchange with the cold demethanizer overhead stream **38** exiting the top of demethanizer **20** at -127°F [-88°C]. The cold demethanizer overhead stream is warmed slightly to -120°F [-84°C] (stream **38a**) as it cools and condenses at least a portion of stream **42**.

[0045] The operating pressure in reflux separator **23** (447 psia [3,079 kPa(a)]) is maintained slightly below the operating pressure of demethanizer **20**. This provides the driving force which causes distillation vapor stream **42** to flow through heat exchanger **22** and thence into the reflux separator **23** wherein the condensed liquid (stream **44**) is separated from any uncondensed vapor (stream **43**). Stream **43** then combines with the warmed demethanizer overhead stream **38a** from heat exchanger **22** to form cold residue gas stream **45** at -120°F [-84°C].

[0046] The liquid stream **44** from reflux separator **23** is pumped by pump **24** to a pressure slightly above the operating pressure of demethanizer **20**, and stream **44a** is then supplied as cold top column feed (reflux) to demethanizer **20**. This cold liquid reflux absorbs and condenses the propane and heavier components rising in the upper rectification region of absorbing section **20a** of demethanizer **20**.

[0047] In stripping section **20b** of demethanizer **20**, the feed streams are stripped of their methane and lighter components. The resulting liquid product (stream **41**) exits the bottom of tower **20** at 114°F [45°C]. The distillation vapor stream forming the tower overhead (stream **38**) is warmed in heat exchanger **22** as it provides cooling to distillation stream **42** as described previously, then combines with stream **43** to form the cold residue gas stream **45**. The residue gas passes countercurrently to the incoming feed gas in heat exchanger **15** where it is heated to -36°F [-38°C] (stream **45a**), in heat exchanger **13** where it is heated to -5°F [-20°C] (stream **45b**), and in heat exchanger **10** where it is heated to 80°F [27°C] (stream **45c**) as it provides cooling as previously described. The residue gas is then re-compressed in two stages, compressor **18** driven by expansion machine **17** and compressor **25** driven by a supplemental power source. After stream **45e** is cooled to 120°F [49°C] in discharge cooler **26**, the residue gas product (stream **45f**) flows to the sales gas pipeline at 1015 psia [6,998 kPa(a)].

[0048] A summary of stream flow rates and energy consumption for the process illustrated in FIG. 3 is set forth in the following table:

Table III

(FIG. 3)

Stream Flow Summary - Lb. Moles/Hr [kg moles/Hr]

Stream	Methane	Ethane	Propane	Butanes+	Total
31	53,228	6,192	3,070	2,912	65,876
32	49,244	4,670	1,650	815	56,795
33	3,984	1,522	1,420	2,097	9,081
34	47,440	4,081	1,204	420	53,536
37	1,804	589	446	395	3,259
35	17,553	1,510	445	155	19,808
36	29,887	2,571	759	265	33,728
38	48,673	811	23	1	49,803
42	5,555	373	22	2	6,000
43	4,423	113	2	0	4,564
44	1,132	260	20	2	1,436
45	53,096	924	25	1	54,367
41	132	5,268	3,045	2,911	11,509

Recoveries*					
Ethane	85.08%				
Propane	99.20%				
Butanes+	99.98%				
Power					
Residue Gas Compression	23,630	HP	[	38,847	kW]
Utility Cooling					
Propane Refrigeration Duty	37,581	MBTU/H	[	24,275	kW]

* (Based on un-rounded flow rates)

[0049] A comparison of Tables I and III shows that, compared to the prior art, the present invention improves ethane recovery from 84.21% to 85.08%, propane recovery from 98.58% to 99.20%, and butanes+ recovery from 99.88% to 99.98%. Comparison of Tables I and III further shows that the improvement in yields was achieved using essentially the same horsepower and utility requirements.

[0050] The improvement in recoveries provided by the present invention is due to the supplemental rectification provided by reflux stream **44a**, which reduces the amount of propane and C_4+ components contained in the inlet feed gas that is lost to the residue gas. Although the expanded substantially condensed feed stream **35b** supplied to absorbing section **20a** of demethanizer **20** provides bulk recovery of the ethane, propane, and heavier hydrocarbon components contained in expanded feed **36a** and the vapors rising from stripping section **20b**, it cannot capture all of the propane and heavier hydrocarbon components due to equilibrium effects because stream **35b** itself contains

propane and heavier hydrocarbon components. However, reflux stream **44a** of the present invention is predominantly liquid methane and ethane and contains very little propane and heavier hydrocarbon components, so that only a small quantity of reflux to the upper rectification section in absorbing section **20a** is sufficient to capture nearly all of the propane and heavier hydrocarbon components. As a result, nearly 100% of the propane and substantially all of the heavier hydrocarbon components are recovered in liquid product **41** leaving the bottom of demethanizer **20**. Due to the bulk liquid recovery provided by expanded substantially condensed feed stream **35b**, the quantity of reflux (stream **44a**) needed is small enough that the cold demethanizer overhead vapor (stream **38**) can provide the refrigeration to generate this reflux without significantly impacting the cooling of feed stream **35** in heat exchanger **15**.

Example 2

[0051] In those cases where the C_2 component recovery level in the liquid product must be reduced (as in the FIG. 2 prior art process described previously, for instance), the present invention offers very significant recovery and efficiency advantages over the prior art process depicted in FIG. 2. The operating conditions of the FIG. 3 process can be altered as illustrated in FIG. 4 to reduce the ethane content in the liquid product of the present invention to the same level as for the FIG. 2 prior art process. The feed gas composition and conditions considered in the process presented in FIG. 4 are the same as those in FIG. 2. Accordingly, the FIG. 4 process can be compared with that of the FIG. 2 process to further illustrate the advantages of the present invention.

[0052] In the simulation of the FIG. 4 process, the inlet gas cooling, separation, and expansion scheme for the processing plant is much the same as that used in FIG. 3. The main difference is that the flash expanded separator liquid streams (streams **33a** and **37a**) are used to provide feed gas cooling, instead of using side reboiler liquids from fractionation tower **20** as shown in FIG. 3. Due to the lower recovery of C_2 components in the tower bottom liquid (stream **41**), the temperatures in fractionation tower **20** are higher, making the tower liquids too warm for effective heat exchange with the feed gas. An additional difference is that a side draw of tower liquids (stream **49**) is used to supplement the cooling provided in heat exchanger **22** by tower overhead vapor stream **38**.

[0053] The feed stream **31** is cooled in heat exchanger **10** by heat exchange with cool residue gas at -5°F [-21°C] (stream **45b**), flash expanded liquids (stream **33a**), and propane refrigerant. The cooled stream **31a** enters separator **11** at 0°F [–18°C] and 955 psia [6,584 kPa(a)] where the vapor (stream **32**) is separated from the condensed liquid (stream **33**). The separator liquid (stream **33**) is expanded to slightly above the operating pressure (approximately 450 psia [3,103 kPa(a)]) of fractionation tower **20** by expansion valve **12**, cooling stream **33a** to -26°F [-32°C] before it enters heat exchanger **10** and is heated as it provides cooling of the incoming feed gas as described earlier. The expanded liquid stream is heated to 75°F [24°C], partially vaporizing stream **33b** before it is supplied to fractionation tower **20** at a lower mid-column feed point.

[0054] The separator vapor (stream **32**) is further cooled in heat exchanger **13** by heat exchange with cool residue gas at -66°F [-54°C] (stream **45a**) and flash expanded

liquids (stream **37a**). The cooled stream **32a** enters separator **14** at -38°F [–39°C] and 950 psia [6,550 kPa(a)] where the vapor (stream **34**) is separated from the condensed liquid (stream **37**). The separator liquid (stream **37**) is expanded to slightly above the operating pressure of fractionation tower **20** by expansion valve **19**, cooling stream **37a** to -75°F [-59°C] before it enters heat exchanger **13** and is heated as it provides cooling of stream **32** as described earlier. The expanded liquid stream is heated to -5°F [-21°C], partially vaporizing stream **37b** before it is supplied to fractionation tower **20** at a second lower mid-column feed point.

[0055] The vapor (stream **34**) from separator **14** is divided into two streams, **35** and **36**. Stream **35**, containing about 15% of the total vapor, passes through heat exchanger **15** in heat exchange relation with the cold residue gas at -82°F [-63°C] (stream **45**) where it is cooled to substantial condensation. The resulting substantially condensed stream **35a** at -77°F [-61°C] is then flash expanded through expansion valve **16** to the operating pressure of fractionation tower **20**. During expansion a portion of the stream is vaporized, resulting in cooling of the total stream. In the process illustrated in FIG. 4, the expanded stream **35b** leaving expansion valve **16** reaches a temperature of -122°F [-85°C] and is supplied to fractionation tower **20** at an upper mid-column feed point.

[0056] The remaining 85% of the vapor from separator **14** (stream **36**) enters a work expansion machine **17** in which mechanical energy is extracted from this portion of the high pressure feed. The machine **17** expands the vapor substantially isentropically to the tower operating pressure, with the work expansion cooling the expanded stream **36a** to a temperature of approximately -93°F [-69°C]. The partially condensed expanded

stream **36a** is thereafter supplied as feed to fractionation tower **20** a lower mid-column feed point.

[0057] A portion of the distillation vapor (stream **42**) is withdrawn from the upper region of the stripping section in fractionation tower **20**. This stream is then cooled from -65°F [-54°C] to -77°F [-60°C] and partially condensed (stream **42a**) in heat exchanger **22** by heat exchange with the cold demethanizer overhead stream **38** exiting the top of demethanizer **20** at -108°F [-78°C] and demethanizer liquid stream **49** at -95°F [-70°C] withdrawn from the lower region of the absorbing section in fractionation tower **20**. The cold demethanizer overhead stream is warmed slightly to -103°F [-75°C] (stream **38a**) and the demethanizer liquid stream is heated to -79°F [-62°C] (stream **49a**) as they cool and condense at least a portion of stream **42**. The heated and partially vaporized stream **49a** is returned to the middle region of the stripping section in demethanizer **20**.

[0058] The operating pressure in reflux separator **23** (447 psia [3,079 kPa(a)]) is maintained slightly below the operating pressure of demethanizer **20**. This pressure differential allows distillation vapor stream **42** to flow through heat exchanger **22** and thence into the reflux separator **23** wherein the condensed liquid (stream **44**) is separated from any uncondensed vapor (stream **43**). Stream **43** then combines with the warmed demethanizer overhead stream **38a** from heat exchanger **22** to form cold residue gas stream **45** at -82°F [-63°C].

[0059] The liquid stream **44** from reflux separator **23** is pumped by pump **24** to a pressure slightly above the operating pressure of demethanizer **20**. The pumped stream **44a** is then divided into at least two portions, streams **52** and **53**. One portion, stream **52**

containing about 50% of the total, is supplied as cold top column feed (reflux) to the absorbing section in demethanizer **20**. This cold liquid reflux absorbs and condenses the propane and heavier components rising in the upper rectification region of the absorbing section of demethanizer **20**. The other portion, stream **53**, is supplied to demethanizer **20** at a mid-column feed position located in the upper region of the stripping section, in substantially the same region where distillation vapor stream **42** is withdrawn, to provide partial rectification of stream **42**.

[0060] The liquid product stream **41** exits the bottom of the tower at 142°F [61°C]. The distillation vapor stream forming the tower overhead (stream **38**) is warmed in heat exchanger **22** as it provides cooling to distillation stream **42** as described previously, then combines with stream **43** to form the cold residue gas stream **45**. The residue gas passes countercurrently to the incoming feed gas in heat exchanger **15** where it is heated to -66°F [-54°C] (stream **45a**), in heat exchanger **13** where it is heated to -5°F [-21°C] (stream **45b**), and in heat exchanger **10** where it is heated to 80°F [27°C] (stream **45c**) as it provides cooling as previously described. The residue gas is then re-compressed in two stages, compressor **18** driven by expansion machine **17** and compressor **25** driven by a supplemental power source. After stream **45e** is cooled to 120°F [49°C] in discharge cooler **26**, the residue gas product (stream **45f**) flows to the sales gas pipeline at 1015 psia [6,998 kPa(a)].

[0061] A summary of stream flow rates and energy consumption for the process illustrated in FIG. 4 is set forth in the following table:

Table IV

(FIG. 4)

Stream Flow Summary - Lb. Moles/Hr [kg moles/Hr]

Stream	Methane	Ethane	Propane	Butanes+	Total
31	53,228	6,192	3,070	2,912	65,876
32	49,244	4,670	1,650	815	56,795
33	3,984	1,522	1,420	2,097	9,081
34	46,206	3,769	1,035	333	51,718
37	3,038	901	615	482	5,077
35	6,931	565	155	50	7,758
36	39,275	3,204	880	283	43,960
38	43,720	2,409	6	0	46,484
49	4,146	2,363	1,034	332	7,962
42	12,721	2,638	13	0	15,589
43	9,429	631	1	0	10,161
44	3,292	2,007	12	0	5,428
45	53,149	3,040	7	0	56,645
41	79	3,152	3,063	2,912	9,231

Recoveries*					
Ethane	50.89%				
Propane	99.78%				
Butanes+	100.00%				
Power					
Residue Gas Compression	23,726	HP	[	39,005	kW]
Utility Cooling					
Propane Refrigeration Duty	30,708	MBTU/H	[	19,836	kW]

* (Based on un-rounded flow rates)

[0062] A comparison of Tables II and IV shows that, compared to the prior art, the present invention improves propane recovery from 96.51% to 99.78% and butanes+ recovery from 99.68% to 100.00%. Comparison of Tables II and IV further shows that the improvement in yields was achieved using essentially the same horsepower and utility requirements.

[0063] Similar to the FIG. 3 embodiment of the present invention, the FIG. 4 embodiment of the present invention improves recoveries by providing supplemental rectification with reflux stream **52**, which reduces the amount of propane and C_4+ components contained in the inlet feed gas that is lost to the residue gas. The FIG. 4 embodiment has the further advantage that splitting the reflux into two streams (streams **52** and **53**) provides not only rectification of demethanizer overhead vapor stream **38**, but partial rectification of distillation vapor stream **42** as well, reducing the amount of C_3 and heavier components in both streams compared to the FIG. 3 embodiment, as can be seen

by comparing Tables III and IV. The result is 0.58 percentage points higher propane recovery than the FIG. 3 embodiment for the FIG. 4 embodiment, even though the ethane recovery level is much lower (50.89% versus 85.08%) for the FIG. 4 embodiment. The present invention allows maintaining a very high recovery level for the propane and heavier components regardless of the ethane recovery level, so that recovery of the propane and heavier components need never be compromised during times when ethane recovery must be curtailed to satisfy other plant constraints.

Other Embodiments

[0064] In accordance with this invention, it is generally advantageous to design the absorbing (rectification) section of the demethanizer to contain multiple theoretical separation stages. However, the benefits of the present invention can be achieved with as few as one theoretical stage, and it is believed that even the equivalent of a fractional theoretical stage may allow achieving these benefits. For instance, all or a part of the pumped condensed liquid (stream **44a**) leaving reflux separator **23** and all or a part of the expanded substantially condensed stream **35b** from expansion valve **16** can be combined (such as in the piping joining the expansion valve to the demethanizer) and if thoroughly intermingled, the vapors and liquids will mix together and separate in accordance with the relative volatilities of the various components of the total combined streams. Such commingling of the two streams shall be considered for the purposes of this invention as constituting an absorbing section.

[0065] Some circumstances may favor mixing the remaining vapor portion of distillation stream **42a** with the fractionation column overhead (stream **38**), then

supplying the mixed stream to heat exchanger **22** to provide cooling of distillation stream **42**. This is shown in FIG. 5, where the mixed stream **45** resulting from combining the reflux separator vapor (stream **43**) with the column overhead (stream **38**) is routed to heat exchanger **22**.

[0066] FIG. 6 depicts a fractionation tower constructed in two vessels, absorber (rectifier) column **27** and stripper column **20**. In such cases, the overhead vapor (stream **50**) from stripper column **20** is split into two portions. One portion (stream **42**) is routed to heat exchanger **22** to generate reflux for absorber column **27** as described earlier. The remaining portion (stream **51**) flows to the lower section of absorber column **27** to be contacted by expanded substantially condensed stream **35b** and reflux liquid (stream **44a**). Pump **28** is used to route the liquids (stream **47**) from the bottom of absorber column **27** to the top of stripper column **20** so that the two towers effectively function as one distillation system. The decision whether to construct the fractionation tower as a single vessel (such as demethanizer **20** in FIGS. 3 through 5) or multiple vessels will depend on a number of factors such as plant size, the distance to fabrication facilities, etc.

[0067] As described earlier, the distillation vapor stream **42** is partially condensed and the resulting condensate used to absorb valuable C_3 components and heavier components from the vapors rising through absorbing section **20a** of demethanizer **20**. However, the present invention is not limited to this embodiment. It may be advantageous, for instance, to treat only a portion of these vapors in this manner, or to use only a portion of the condensate as an absorbent, in cases where other design considerations indicate portions of the vapors or the condensate should bypass absorbing

section **20a** of demethanizer **20**. Some circumstances may favor total condensation, rather than partial condensation, of distillation stream **42** in heat exchanger **22**. Other circumstances may favor that distillation stream **42** be a total vapor side draw from fractionation column **20** rather than a partial vapor side draw. It should also be noted that, depending on the composition of the feed gas stream, it may be advantageous to use external refrigeration to provide partial cooling of distillation vapor stream **42** in heat exchanger **22**.

[0068] Feed gas conditions, plant size, available equipment, or other factors may indicate that elimination of work expansion machine **17**, or replacement with an alternate expansion device (such as an expansion valve), is feasible. Although individual stream expansion is depicted in particular expansion devices, alternative expansion means may be employed where appropriate. For example, conditions may warrant work expansion of the substantially condensed portion of the feed stream (stream **35a**).

[0069] In the practice of the present invention, there will necessarily be a slight pressure difference between demethanizer **20** and reflux separator **23** which must be taken into account. If the distillation vapor stream **42** passes through heat exchanger **22** and into reflux separator **23** without any boost in pressure, the reflux separator shall necessarily assume an operating pressure slightly below the operating pressure of demethanizer **20**. In this case, the liquid stream withdrawn from the reflux separator can be pumped to its feed position(s) in the demethanizer. An alternative is to provide a booster blower for distillation vapor stream **42** to raise the operating pressure in heat

exchanger **22** and reflux separator **23** sufficiently so that the liquid stream **44** can be supplied to demethanizer **20** without pumping.

[0070] In those circumstances when the fractionation column is constructed as two vessels, it may be desirable to operate absorber column **27** at higher pressure than stripper column **20** as shown in FIG. 7. One manner of doing so is to use a separate compressor, such as compressor **29** in FIG. 7, to provide the motive force to cause distillation stream **42** to flow through heat exchanger **22**. In such instances, the liquids from the bottom of absorber column **27** (stream **47**) will be at elevated pressure relative to stripper column **20**, so that a pump is not required to direct these liquids to stripper column **20**. Instead, a suitable expansion device, such as expansion valve **28** in FIG. 7, can be used to expand the liquids to the operating pressure of stripper column **20** and the expanded stream **48a** thereafter supplied to stripper column **20**.

[0071] When the inlet gas is leaner, separator **11** in FIGS. 3 and 4 may not be justified. In such cases, the feed gas cooling accomplished in heat exchangers **10** and **13** in FIGS. 3 and 4 may be accomplished without an intervening separator as shown in FIGS. 5 through 7. The decision of whether or not to cool and separate the feed gas in multiple steps will depend on the richness of the feed gas, plant size, available equipment, etc. Depending on the quantity of heavier hydrocarbons in the feed gas and the feed gas pressure, the cooled feed stream **31a** leaving heat exchanger **10** in FIGS. 3 through 7 and/or the cooled stream **32a** leaving heat exchanger **13** in FIGS. 3 and 4 may not contain any liquid (because it is above its dewpoint, or because it is above its

cricondenbar), so that separator **11** shown in FIGS. 3 through 7 and/or separator **14** shown in FIGS. 3 and 4 are not required.

[0072] The high pressure liquid (stream **37** in FIGS. 3 and 4 and stream **33** in FIGS. 5 through 7) need not be expanded and fed to a mid-column feed point on the distillation column. Instead, all or a portion of it may be combined with the portion of the separator vapor (stream **34** in FIGS. 3 through 7) flowing to heat exchanger **15**. (This is shown by the dashed stream **46** in FIGS. 5 through 7.) Any remaining portion of the liquid may be expanded through an appropriate expansion device, such as an expansion valve or expansion machine, and fed to a mid-column feed point on the distillation column (stream **37a** in FIGS. 5 through 7). Stream **33** in FIGS. 3 and 4 and stream **37** in FIGS. 3 through 7 may also be used for inlet gas cooling or other heat exchange service before or after the expansion step prior to flowing to the demethanizer, similar to what is shown in FIG. 4.

[0073] In accordance with this invention, the use of external refrigeration to supplement the cooling available to the inlet gas from other process streams may be employed, particularly in the case of a rich inlet gas. The use and distribution of separator liquids and demethanizer side draw liquids for process heat exchange, and the particular arrangement of heat exchangers for inlet gas cooling must be evaluated for each particular application, as well as the choice of process streams for specific heat exchange services.

[0074] Some circumstances may favor using a portion of the cold distillation liquid leaving absorbing section **20a** for heat exchange, such as stream **49** in FIG. 4 and

dashed stream **49** in FIG. 5. Although only a portion of the liquid from absorbing section **20a** can be used for process heat exchange without reducing the ethane recovery in demethanizer **20**, more duty can sometimes be obtained from these liquids than with liquids from stripping section **20b**. This is because the liquids in absorbing section **20a** of demethanizer **20** are available at a colder temperature level than those in stripping section **20b**. This same feature can be accomplished when fractionation tower **20** is constructed as two vessels, as shown by dashed stream **49** in FIGS. 6 and 7. When the liquids from absorber column **27** are pumped as in FIG. 6, the liquid (stream **47a**) leaving pump **28** can be split into two portions, with one portion (stream **49**) used for heat exchange and then routed to a mid-column feed position on stripper column **20** (stream **49a**). The remaining portion (stream **48**) becomes the top feed to stripper column **20**. Similarly, when absorber column **27** operates at elevated pressure relative to stripper column **20** as in FIG. 7, the liquid stream **47** can be split into two portions, with one portion (stream **49**) expanded to the operating pressure of stripper column **20** (stream **49a**), used for heat exchange, and then routed to a mid-column feed position on stripper column **20** (stream **49b**). The remaining portion (stream **48**) is likewise expanded to the operating pressure of stripper column **20** and stream **48a** then becomes the top feed to stripper column **20**. As shown by stream **53** in FIG. 4 and by dashed stream **53** in FIGS. 5 through 7, in such cases it may be advantageous to split the liquid stream from reflux pump **24** (stream **44a**) into at least two streams so that a portion (stream **53**) can be supplied to the stripping section of fractionation tower **20** (FIGS. 4 and 5) or to stripper column **20** (FIGS. 6 and 7) to increase the liquid flow in that part of the distillation

system and improve the rectification of stream **42**, while the remaining portion (stream **52**) is supplied to the top of absorbing section **20a** (FIGS. 4 and 5) or to the top of absorber column **27** (FIGS. 6 and 7).

[0075] In accordance with this invention, the splitting of the vapor feed may be accomplished in several ways. In the processes of FIGS. 3 through 7, the splitting of vapor occurs following cooling and separation of any liquids which may have been formed. The high pressure gas may be split, however, prior to any cooling of the inlet gas or after the cooling of the gas and prior to any separation stages. In some embodiments, vapor splitting may be effected in a separator.

[0076] It will also be recognized that the relative amount of feed found in each branch of the split vapor feed will depend on several factors, including gas pressure, feed gas composition, the amount of heat which can economically be extracted from the feed, and the quantity of horsepower available. More feed to the top of the column may increase recovery while decreasing power recovered from the expander thereby increasing the recompression horsepower requirements. Increasing feed lower in the column reduces the horsepower consumption but may also reduce product recovery. The relative locations of the mid-column feeds may vary depending on inlet composition or other factors such as desired recovery levels and amount of liquid formed during inlet gas cooling. Moreover, two or more of the feed streams, or portions thereof, may be combined depending on the relative temperatures and quantities of individual streams, and the combined stream then fed to a mid-column feed position.

[0077] The present invention provides improved recovery of C_3 components and heavier hydrocarbon components per amount of utility consumption required to operate the process. An improvement in utility consumption required for operating the demethanizer process may appear in the form of reduced power requirements for compression or re-compression, reduced power requirements for external refrigeration, reduced energy requirements for tower reboilers, or a combination thereof.

[0078] While there have been described what are believed to be preferred embodiments of the invention, those skilled in the art will recognize that other and further modifications may be made thereto, e.g. to adapt the invention to various conditions, types of feed, or other requirements without departing from the spirit of the present invention as defined by the following claims.

WE CLAIM:

1. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein following cooling, said cooled stream is divided into first and second streams; and

(1) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(2) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to said distillation column;

(3) said second stream is expanded to said lower pressure and is supplied to said distillation column at a second mid-column feed position;

(4) a vapor distillation stream is withdrawn from a region of said distillation column below said expanded second stream and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(5) at least a portion of said condensed stream is supplied to said distillation column at a top feed position;

(6) an overhead vapor stream is withdrawn from an upper region of said distillation column and is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (4), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(7) the quantities and temperatures of said feed streams to said distillation column are effective to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

2. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein following cooling, said cooled stream is divided into first and second streams; and

(1) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(2) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to said distillation column;

(3) said second stream is expanded to said lower pressure and is supplied to said distillation column at a second mid-column feed position;

(4) a vapor distillation stream is withdrawn from a region of said distillation column below said expanded second stream and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(5) at least a portion of said condensed stream is supplied to said distillation column at a top feed position;

(6) an overhead vapor stream is withdrawn from an upper region of said distillation column and combined with said residual vapor stream to form a combined vapor stream;

(7) said combined vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (4), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(8) the quantities and temperatures of said feed streams to said distillation column are effective to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

3. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein prior to cooling, said gas is divided into first and second streams; and

(1) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(2) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to said distillation column;

(3) said second stream is cooled and thereafter expanded to said lower pressure and supplied to said distillation column at a second mid-column feed position;

(4) a vapor distillation stream is withdrawn from a region of said distillation column below said expanded cooled second stream and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(5) at least a portion of said condensed stream is supplied to said distillation column at a top feed position;

(6) an overhead vapor stream is withdrawn from an upper region of said distillation column and is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (4), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(7) the quantities and temperatures of said feed streams to said distillation column are effective to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

4. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein prior to cooling, said gas is divided into first and second streams; and

(1) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(2) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to said distillation column;

(3) said second stream is cooled and thereafter expanded to said lower pressure and supplied to said distillation column at a second mid-column feed position;

(4) a vapor distillation stream is withdrawn from a region of said distillation column below said expanded cooled second stream and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(5) at least a portion of said condensed stream is supplied to said distillation column at a top feed position;

(6) an overhead vapor stream is withdrawn from an upper region of said distillation column and combined with said residual vapor stream to form a combined vapor stream;

(7) said combined vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (4), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(8) the quantities and temperatures of said feed streams to said distillation column are effective to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

5. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein said gas stream is cooled sufficiently to partially condense it; and

(1) said partially condensed gas stream is separated thereby to provide a vapor stream and at least one liquid stream;

(2) said vapor stream is thereafter divided into first and second streams;

(3) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(4) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to said distillation column;

(5) said second stream is expanded to said lower pressure and is supplied to said distillation column at a second mid-column feed position;

(6) at least a portion of said at least one liquid stream is expanded to said lower pressure and is supplied to said distillation column at a third mid-column feed position;

(7) a vapor distillation stream is withdrawn from a region of said distillation column below said expanded second stream and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(8) at least a portion of said condensed stream is supplied to said distillation column at a top feed position;

(9) an overhead vapor stream is withdrawn from an upper region of said distillation column and is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(10) the quantities and temperatures of said feed streams to said distillation column are effective to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

6. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein said gas stream is cooled sufficiently to partially condense it; and

(1) said partially condensed gas stream is separated thereby to provide a vapor stream and at least one liquid stream;

(2) said vapor stream is thereafter divided into first and second streams;

(3) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(4) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to said distillation column;

(5) said second stream is expanded to said lower pressure and is supplied to said distillation column at a second mid-column feed position;

(6) at least a portion of said at least one liquid stream is expanded to said lower pressure and is supplied to said distillation column at a third mid-column feed position;

(7) a vapor distillation stream is withdrawn from a region of said distillation column below said expanded second stream and is cooled sufficiently to

condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(8) at least a portion of said condensed stream is supplied to said distillation column at a top feed position;

(9) an overhead vapor stream is withdrawn from an upper region of said distillation column and combined with said residual vapor stream to form a combined vapor stream;

(10) said combined vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(11) the quantities and temperatures of said feed streams to said distillation column are effective to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

7. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein said gas stream is cooled sufficiently to partially condense it; and

(1) said partially condensed gas stream is separated thereby to provide a vapor stream and at least one liquid stream;

(2) said vapor stream is thereafter divided into first and second streams;

(3) said first stream is combined with at least a portion of said at least one liquid stream to form a combined stream, and said combined stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(4) said expanded cooled combined stream is thereafter supplied at a first mid-column feed position to said distillation column;

(5) said second stream is expanded to said lower pressure and is supplied to said distillation column at a second mid-column feed position;

(6) any remaining portion of said at least one liquid stream is expanded to said lower pressure and is supplied to said distillation column at a third mid-column feed position;

(7) a vapor distillation stream is withdrawn from a region of said distillation column below said expanded second stream and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(8) at least a portion of said condensed stream is supplied to said distillation column at a top feed position;

(9) an overhead vapor stream is withdrawn from an upper region of said distillation column and is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(10) the quantities and temperatures of said feed streams to said distillation column are effective to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

8. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein said gas stream is cooled sufficiently to partially condense it; and

(1) said partially condensed gas stream is separated thereby to provide a vapor stream and at least one liquid stream;

(2) said vapor stream is thereafter divided into first and second streams;

(3) said first stream is combined with at least a portion of said at least one liquid stream to form a combined stream, and said combined stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(4) said expanded cooled combined stream is thereafter supplied at a first mid-column feed position to said distillation column;

(5) said second stream is expanded to said lower pressure and is supplied to said distillation column at a second mid-column feed position;

(6) any remaining portion of said at least one liquid stream is expanded to said lower pressure and is supplied to said distillation column at a third mid-column feed position;

(7) a vapor distillation stream is withdrawn from a region of said distillation column below said expanded second stream and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(8) at least a portion of said condensed stream is supplied to said distillation column at a top feed position;

(9) an overhead vapor stream is withdrawn from an upper region of said distillation column and combined with said residual vapor stream to form a combined vapor stream;

(10) said combined vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(11) the quantities and temperatures of said feed streams to said distillation column are effective to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

9. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein prior to cooling, said gas is divided into first and second streams; and

(1) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(2) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to said distillation column;

(3) said second stream is cooled under pressure sufficiently to partially condense it;

(4) said partially condensed second stream is separated thereby to provide a vapor stream and at least one liquid stream;

(5) said vapor stream is expanded to said lower pressure and supplied to said distillation column at a second mid-column feed position;

(6) at least a portion of said at least one liquid stream is expanded to said lower pressure and is supplied to said distillation column at a third mid-column feed position;

(7) a vapor distillation stream is withdrawn from a region of said distillation column below said expanded vapor stream and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(8) at least a portion of said condensed stream is supplied to said distillation column at a top feed position;

(9) an overhead vapor stream is withdrawn from an upper region of said distillation column and is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(10) the quantities and temperatures of said feed streams to said distillation column are effective to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

10. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein prior to cooling, said gas is divided into first and second streams; and

(1) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(2) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to said distillation column;

(3) said second stream is cooled under pressure sufficiently to partially condense it;

(4) said partially condensed second stream is separated thereby to provide a vapor stream and at least one liquid stream;

(5) said vapor stream is expanded to said lower pressure and supplied to said distillation column at a second mid-column feed position;

(6) at least a portion of said at least one liquid stream is expanded to said lower pressure and is supplied to said distillation column at a third mid-column feed position;

(7) a vapor distillation stream is withdrawn from a region of said distillation column below said expanded vapor stream and is cooled sufficiently to

condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(8) at least a portion of said condensed stream is supplied to said distillation column at a top feed position;

(9) an overhead vapor stream is withdrawn from an upper region of said distillation column and combined with said residual vapor stream to form a combined vapor stream;

(10) said combined vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(11) the quantities and temperatures of said feed streams to said distillation column are effective to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

11. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein following cooling, said cooled stream is divided into first and second streams; and

(1) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(2) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to a contacting and separating device that produces an overhead vapor stream and a bottom liquid stream, whereupon said bottom liquid stream is supplied to said distillation column;

(3) said second stream is expanded to said lower pressure and is supplied to said contacting and separating device at a second mid-column feed position;

(4) a vapor distillation stream is withdrawn from an upper region of said distillation column and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(5) at least a portion of said condensed stream is supplied to said contacting and separating device at a top feed position;

(6) said overhead vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (4), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(7) the quantities and temperatures of said feed streams to said contacting and separating device are effective to maintain the overhead temperature of said contacting and separating device at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

12. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein following cooling, said cooled stream is divided into first and second streams; and

(1) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(2) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to a contacting and separating device that produces an overhead vapor stream and a bottom liquid stream, whereupon said bottom liquid stream is supplied to said distillation column;

(3) said second stream is expanded to said lower pressure and is supplied to said contacting and separating device at a second mid-column feed position;

(4) a vapor distillation stream is withdrawn from an upper region of said distillation column and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(5) at least a portion of said condensed stream is supplied to said contacting and separating device at a top feed position;

(6) said overhead vapor stream is combined with said residual vapor stream to form a combined vapor stream;

(7) said combined vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (4), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(8) the quantities and temperatures of said feed streams to said contacting and separating device are effective to maintain the overhead temperature of

said contacting and separating device at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

13. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein prior to cooling, said gas is divided into first and second streams; and

(1) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(2) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to a contacting and separating device that produces an overhead vapor stream and a bottom liquid stream, whereupon said bottom liquid stream is supplied to said distillation column;

(3) said second stream is cooled and thereafter expanded to said lower pressure and is supplied to said contacting and separating device at a second mid-column feed position;

(4) a vapor distillation stream is withdrawn from an upper region of said distillation column and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(5) at least a portion of said condensed stream is supplied to said contacting and separating device at a top feed position;

(6) said overhead vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (4), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(7) the quantities and temperatures of said feed streams to said contacting and separating device are effective to maintain the overhead temperature of said contacting and separating device at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

14. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein prior to cooling, said gas is divided into first and second streams; and

(1) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(2) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to a contacting and separating device that produces an overhead vapor stream and a bottom liquid stream, whereupon said bottom liquid stream is supplied to said distillation column;

(3) said second stream is cooled and thereafter expanded to said lower pressure and is supplied to said contacting and separating device at a second mid-column feed position;

(4) a vapor distillation stream is withdrawn from an upper region of said distillation column and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(5) at least a portion of said condensed stream is supplied to said contacting and separating device at a top feed position;

(6) said overhead vapor stream is combined with said residual vapor stream to form a combined vapor stream;

(7) said combined vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (4), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(8) the quantities and temperatures of said feed streams to said contacting and separating device are effective to maintain the overhead temperature of said contacting and separating device at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

15. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein said gas stream is cooled sufficiently to partially condense it; and

(1) said partially condensed gas stream is separated thereby to provide a vapor stream and at least one liquid stream;

(2) said vapor stream is thereafter divided into first and second streams;

(3) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(4) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to a contacting and separating device that produces an overhead vapor stream and a bottom liquid stream, whereupon said bottom liquid stream is supplied to said distillation column;

(5) said second stream is expanded to said lower pressure and is supplied to said contacting and separating device at a second mid-column feed position;

(6) at least a portion of said at least one liquid stream is expanded to said lower pressure and is supplied to said contacting and separating device at a third mid-column feed position;

(7) a vapor distillation stream is withdrawn from an upper region of said distillation column and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(8) at least a portion of said condensed stream is supplied to said contacting and separating device at a top feed position;

(9) said overhead vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(10) the quantities and temperatures of said feed streams to said contacting and separating device are effective to maintain the overhead temperature of said contacting and separating device at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

16. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein said gas stream is cooled sufficiently to partially condense it; and

(1) said partially condensed gas stream is separated thereby to provide a vapor stream and at least one liquid stream;

(2) said vapor stream is thereafter divided into first and second streams;

(3) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(4) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to a contacting and separating device that produces an overhead vapor stream and a bottom liquid stream, whereupon said bottom liquid stream is supplied to said distillation column;

(5) said second stream is expanded to said lower pressure and is supplied to said contacting and separating device at a second mid-column feed position;

(6) at least a portion of said at least one liquid stream is expanded to said lower pressure and is supplied to said contacting and separating device at a third mid-column feed position;

(7) a vapor distillation stream is withdrawn from an upper region of said distillation column and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(8) at least a portion of said condensed stream is supplied to said contacting and separating device at a top feed position;

(9) said overhead vapor stream is combined with said residual vapor stream to form a combined vapor stream;

(10) said combined vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(11) the quantities and temperatures of said feed streams to said contacting and separating device are effective to maintain the overhead temperature of said contacting and separating device at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

17. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein said gas stream is cooled sufficiently to partially condense it; and

(1) said partially condensed gas stream is separated thereby to provide a vapor stream and at least one liquid stream;

(2) said vapor stream is thereafter divided into first and second streams;

(3) said first stream is combined with at least a portion of said at least one liquid stream to form a combined stream, and said combined stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(4) said expanded cooled combined stream is thereafter supplied at a first mid-column feed position to a contacting and separating device that produces an overhead vapor stream and a bottom liquid stream, whereupon said bottom liquid stream is supplied to said distillation column;

(5) said second stream is expanded to said lower pressure and is supplied to said contacting and separating device at a second mid-column feed position;

(6) any remaining portion of said at least one liquid stream is expanded to said lower pressure and is supplied to said contacting and separating device at a third mid-column feed position;

(7) a vapor distillation stream is withdrawn from an upper region of said distillation column and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(8) at least a portion of said condensed stream is supplied to said contacting and separating device at a top feed position;

(9) said overhead vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(10) the quantities and temperatures of said feed streams to said contacting and separating device are effective to maintain the overhead temperature of said contacting and separating device at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

18. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein said gas stream is cooled sufficiently to partially condense it; and

(1) said partially condensed gas stream is separated thereby to provide a vapor stream and at least one liquid stream;

(2) said vapor stream is thereafter divided into first and second streams;

(3) said first stream is combined with at least a portion of said at least one liquid stream to form a combined stream, and said combined stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(4) said expanded cooled combined stream is thereafter supplied at a first mid-column feed position to a contacting and separating device that produces an overhead vapor stream and a bottom liquid stream, whereupon said bottom liquid stream is supplied to said distillation column;

(5) said second stream is expanded to said lower pressure and is supplied to said contacting and separating device at a second mid-column feed position;

(6) any remaining portion of said at least one liquid stream is expanded to said lower pressure and is supplied to said contacting and separating device at a third mid-column feed position;

(7) a vapor distillation stream is withdrawn from an upper region of said distillation column and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(8) at least a portion of said condensed stream is supplied to said contacting and separating device at a top feed position;

(9) said overhead vapor stream is combined with said residual vapor stream to form a combined vapor stream;

(10) said combined vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(11) the quantities and temperatures of said feed streams to said contacting and separating device are effective to maintain the overhead temperature of said contacting and separating device at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

19. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein prior to cooling, said gas is divided into first and second streams; and

(1) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(2) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to a contacting and separating device that produces an overhead vapor stream and a bottom liquid stream, whereupon said bottom liquid stream is supplied to said distillation column;

(3) said second stream is cooled under pressure sufficiently to partially condense it;

(4) said partially condensed second stream is separated thereby to provide a vapor stream and at least one liquid stream;

(5) said vapor stream is expanded to said lower pressure and supplied to said contacting and separating device at a second mid-column feed position;

(6) at least a portion of said at least one liquid stream is expanded to said lower pressure and is supplied to said contacting and separating device at a third mid-column feed position;

(7) a vapor distillation stream is withdrawn from an upper region of said distillation column and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(8) at least a portion of said condensed stream is supplied to said contacting and separating device at a top feed position;

(9) said overhead vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(10) the quantities and temperatures of said feed streams to said contacting and separating device are effective to maintain the overhead temperature of said contacting and separating device at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

20. In a process for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile

residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in which process

(a) said gas stream is cooled under pressure to provide a cooled stream;

(b) said cooled stream is expanded to a lower pressure whereby it is further cooled; and

(c) said further cooled stream is directed into a distillation column and fractionated at said lower pressure whereby the components of said relatively less volatile fraction are recovered;

the improvement wherein prior to cooling, said gas is divided into first and second streams; and

(1) said first stream is cooled to condense substantially all of it and is thereafter expanded to said lower pressure whereby it is further cooled;

(2) said expanded cooled first stream is thereafter supplied at a first mid-column feed position to a contacting and separating device that produces an overhead vapor stream and a bottom liquid stream, whereupon said bottom liquid stream is supplied to said distillation column;

(3) said second stream is cooled under pressure sufficiently to partially condense it;

(4) said partially condensed second stream is separated thereby to provide a vapor stream and at least one liquid stream;

(5) said vapor stream is expanded to said lower pressure and supplied to said contacting and separating device at a second mid-column feed position;

(6) at least a portion of said at least one liquid stream is expanded to said lower pressure and is supplied to said contacting and separating device at a third mid-column feed position;

(7) a vapor distillation stream is withdrawn from an upper region of said distillation column and is cooled sufficiently to condense at least a part of it, thereby forming a residual vapor stream and a condensed stream;

(8) at least a portion of said condensed stream is supplied to said contacting and separating device at a top feed position;

(9) said overhead vapor stream is combined with said residual vapor stream to form a combined vapor stream;

(10) said combined vapor stream is directed into heat exchange relation with said vapor distillation stream and heated, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(11) the quantities and temperatures of said feed streams to said contacting and separating device are effective to maintain the overhead temperature of said contacting and separating device at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

21. The improvement according to claim 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 wherein

(1) said condensed stream is divided into at least a first portion and a second portion;

(2) said first portion is supplied to said distillation column at a top feed position; and

(3) said second portion is supplied to said distillation column at a feed position in substantially the same region wherein said vapor distillation stream is withdrawn.

22. The improvement according to claim 11, 12, 13, 14, 15, 16, 17, 18, 19, or 20 wherein

(1) said condensed stream is divided into at least a first portion and a second portion;

(2) said first portion is supplied to said contacting and separating device at a top feed position; and

(3) said second portion is supplied to said distillation column at a top feed position.

23. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into an overhead vapor stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) dividing means connected to said first cooling means to receive said cooled stream and to divide it into first and second streams;

(2) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(3) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to said distillation column to supply said expanded cooled first stream to said distillation column at a first mid-column feed position;

(4) said first expansion means being connected to said dividing means to receive said second stream and to expand it to said lower pressure, said first expansion means being further connected to said distillation column to supply said expanded second stream to said distillation column at a second mid-column feed position;

(5) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from a region of said distillation column below said expanded second stream;

(6) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(7) separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said separating means being further connected to said distillation column to supply at least a portion of said condensed stream to said distillation column at a top feed position;

(8) said distillation column being further connected to said heat exchange means to direct at least a portion of said overhead vapor stream separated therein into heat exchange relation with said vapor distillation stream and heat said overhead vapor stream, thereby to supply at least a portion of the cooling of step (6), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(9) control means adapted to regulate the quantities and temperatures of said feed streams to said distillation column to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

24. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into an overhead vapor stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) dividing means connected to said first cooling means to receive said cooled stream and to divide it into first and second streams;

(2) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(3) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to said distillation column

to supply said expanded cooled first stream to said distillation column at a first mid-column feed position;

(4) said first expansion means being connected to said dividing means to receive said second stream and to expand it to said lower pressure, said first expansion means being further connected to said distillation column to supply said expanded second stream to said distillation column at a second mid-column feed position;

(5) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from a region of said distillation column below said expanded second stream;

(6) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(7) separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said separating means being further connected to said distillation column to supply at least a portion of said condensed stream to said distillation column at a top feed position;

(8) combining means connected to said distillation column and said separating means to receive said overhead vapor stream and said residual vapor stream and form a combined vapor stream;

(9) said combining means being further connected to said heat exchange means to direct at least a portion of said combined vapor stream into heat

exchange relation with said vapor distillation stream and heat said combined vapor stream, thereby to supply at least a portion of the cooling of step (6), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(10) control means adapted to regulate the quantities and temperatures of said feed streams to said distillation column to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

25. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into an overhead vapor stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) dividing means prior to said first cooling means to divide said feed gas into first and second streams;

(2) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(3) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to said distillation column to supply said expanded cooled first stream to said distillation column at a first mid-column feed position;

(4) said first cooling means being connected to said dividing means to receive said second stream and to cool it;

(5) said first expansion means being connected to said first cooling means to receive said cooled second stream and to expand it to said lower pressure, said first expansion means being further connected to said distillation column to supply said expanded cooled second stream to said distillation column at a second mid-column feed position;

(6) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from a region of said distillation column below said expanded cooled second stream;

(7) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(8) separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said separating means being further connected to said distillation column to supply at least a portion of said condensed stream to said distillation column at a top feed position;

(9) said distillation column being further connected to said heat exchange means to direct at least a portion of said overhead vapor stream separated therein into heat exchange relation with said vapor distillation stream and heat said overhead vapor stream, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(10) control means adapted to regulate the quantities and temperatures of said feed streams to said distillation column to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

26. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into an overhead vapor stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) dividing means prior to said first cooling means to divide said feed gas into first and second streams;

(2) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(3) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to said distillation column to supply said expanded cooled first stream to said distillation column at a first mid-column feed position;

(4) said first cooling means being connected to said dividing means to receive said second stream and to cool it;

(5) said first expansion means being connected to said first cooling means to receive said cooled second stream and to expand it to said lower pressure, said first expansion means being further connected to said distillation column to

supply said expanded cooled second stream to said distillation column at a second mid-column feed position;

(6) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from a region of said distillation column below said expanded cooled second stream;

(7) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(8) separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said separating means being further connected to said distillation column to supply at least a portion of said condensed stream to said distillation column at a top feed position;

(9) combining means connected to said distillation column and said separating means to receive said overhead vapor stream and said residual vapor stream and form a combined vapor stream;

(10) said combining means being further connected to said heat exchange means to direct at least a portion of said combined vapor stream into heat exchange relation with said vapor distillation stream and heat said combined vapor stream, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(11) control means adapted to regulate the quantities and temperatures of said feed streams to said distillation column to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

27. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into an overhead vapor stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) said first cooling means being adapted to cool said feed gas under pressure sufficiently to partially condense it;

(2) first separating means connected to said first cooling means to receive said partially condensed feed and to separate it into a vapor stream and at least one liquid stream;

(3) dividing means connected to said first separating means to receive said vapor stream and to divide it into first and second streams;

(4) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(5) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to said distillation column to supply said expanded cooled first stream to said distillation column at a first mid-column feed position;

(6) said first expansion means being connected to said dividing means to receive said second stream and to expand it to said lower pressure, said first expansion means being further connected to said distillation column to supply said expanded second stream to said distillation column at a second mid-column feed position;

(7) third expansion means connected to said first separating means to receive at least a portion of said at least one liquid stream and to expand it to said lower pressure, said third expansion means being further connected to said distillation column to supply said expanded liquid stream to said distillation column at a third mid-column feed position;

(8) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from a region of said distillation column below said expanded second stream;

(9) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(10) second separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said second separating means being further connected to said distillation column to supply at least a portion of said condensed stream to said distillation column at a top feed position;

(11) said distillation column being further connected to said heat exchange means to direct at least a portion of said overhead vapor stream separated therein into heat exchange relation with said vapor distillation stream and heat said overhead vapor stream, thereby to supply at least a portion of the cooling of step (9), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(12) control means adapted to regulate the quantities and temperatures of said feed streams to said distillation column to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

28. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into an overhead vapor stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) said first cooling means being adapted to cool said feed gas under pressure sufficiently to partially condense it;

(2) first separating means connected to said first cooling means to receive said partially condensed feed and to separate it into a vapor stream and at least one liquid stream;

(3) dividing means connected to said first separating means to receive said vapor stream and to divide it into first and second streams;

(4) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(5) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to said distillation column to supply said expanded cooled first stream to said distillation column at a first mid-column feed position;

(6) said first expansion means being connected to said dividing means to receive said second stream and to expand it to said lower pressure, said first expansion means being further connected to said distillation column to supply said expanded second stream to said distillation column at a second mid-column feed position;

(7) third expansion means connected to said first separating means to receive at least a portion of said at least one liquid stream and to expand it to said lower pressure, said third expansion means being further connected to said distillation column to supply said expanded liquid stream to said distillation column at a third mid-column feed position;

(8) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from a region of said distillation column below said expanded second stream;

(9) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(10) second separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said second separating means being further connected to said distillation column to supply at least a portion of said condensed stream to said distillation column at a top feed position;

(11) combining means connected to said distillation column and said second separating means to receive said overhead vapor stream and said residual vapor stream and form a combined vapor stream;

(12) said combining means being further connected to said heat exchange means to direct at least a portion of said combined vapor stream into heat exchange relation with said vapor distillation stream and heat said combined vapor stream, thereby to supply at least a portion of the cooling of step (9), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(13) control means adapted to regulate the quantities and temperatures of said feed streams to said distillation column to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

29. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major

portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into an overhead vapor stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) said first cooling means being adapted to cool said feed gas under pressure sufficiently to partially condense it;

(2) first separating means connected to said first cooling means to receive said partially condensed feed and to separate it into a vapor stream and at least one liquid stream;

(3) dividing means connected to said first separating means to receive said vapor stream and to divide it into first and second streams;

(4) combining means connected to said dividing means and said first separating means to receive said first stream and at least a portion of said at least one liquid stream and form a combined stream;

(5) second cooling means connected to said combining means to receive said combined stream and to cool it sufficiently to substantially condense it;

(6) second expansion means connected to said second cooling means to receive said substantially condensed combined stream and to expand it to said lower pressure, said second expansion means being further connected to said distillation column to supply said expanded cooled combined stream to said distillation column at a first mid-column feed position;

(7) said first expansion means being connected to said dividing means to receive said second stream and to expand it to said lower pressure, said first expansion means being further connected to said distillation column to supply said expanded second stream to said distillation column at a second mid-column feed position;

(8) third expansion means being connected to said first separating means to receive any remaining portion of said at least one liquid stream and to expand it to said lower pressure, said third expansion means being further connected to said distillation column to supply said expanded liquid stream to said distillation column at a third mid-column feed position;

(9) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from a region of said distillation column below said expanded second stream;

(10) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(11) second separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said second separating means being further connected to said distillation column to supply at least a portion of said condensed stream to said distillation column at a top feed position;

(12) said distillation column being further connected to said heat exchange means to direct at least a portion of said overhead vapor stream separated therein into heat exchange relation with said vapor distillation stream and heat said overhead vapor stream, thereby to supply at least a portion of the cooling of step (10), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(13) control means adapted to regulate the quantities and temperatures of said feed streams to said distillation column to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

30. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into an overhead vapor stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) said first cooling means being adapted to cool said feed gas under pressure sufficiently to partially condense it;

(2) first separating means connected to said first cooling means to receive said partially condensed feed and to separate it into a vapor stream and at least one liquid stream;

(3) dividing means connected to said first separating means to receive said vapor stream and to divide it into first and second streams;

(4) first combining means connected to said dividing means and said first separating means to receive said first stream and at least a portion of said at least one liquid stream and form a combined stream;

(5) second cooling means connected to said first combining means to receive said combined stream and to cool it sufficiently to substantially condense it;

(6) second expansion means connected to said second cooling means to receive said substantially condensed combined stream and to expand it to said

lower pressure, said second expansion means being further connected to said distillation column to supply said expanded cooled combined stream to said distillation column at a first mid-column feed position;

(7) said first expansion means being connected to said dividing means to receive said second stream and to expand it to said lower pressure, said first expansion means being further connected to said distillation column to supply said expanded second stream to said distillation column at a second mid-column feed position;

(8) third expansion means being connected to said first separating means to receive any remaining portion of said at least one liquid stream and to expand it to said lower pressure, said third expansion means being further connected to said distillation column to supply said expanded liquid stream to said distillation column at a third mid-column feed position;

(9) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from a region of said distillation column below said expanded second stream;

(10) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(11) second separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said second separating means

being further connected to said distillation column to supply at least a portion of said condensed stream to said distillation column at a top feed position;

(12) second combining means connected to said distillation column and said second separating means to receive said overhead vapor stream and said residual vapor stream and form a combined vapor stream;

(13) said second combining means being further connected to said heat exchange means to direct at least a portion of said combined vapor stream into heat exchange relation with said vapor distillation stream and heat said combined vapor stream, thereby to supply at least a portion of the cooling of step (10), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(14) control means adapted to regulate the quantities and temperatures of said feed streams to said distillation column to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

31. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into an overhead vapor stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) dividing means prior to said first cooling means to divide said feed gas into first and second streams;

(2) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(3) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to said distillation column to supply said expanded cooled first stream to said distillation column at a first mid-column feed position;

(4) said first cooling means being connected to said first dividing means to receive said second stream, said first cooling means being adapted to cool said second stream under pressure sufficiently to partially condense it;

(5) first separating means connected to said first cooling means to receive said partially condensed second stream and to separate it into a vapor stream and at least one liquid stream;

(6) said first expansion means being connected to said first separating means to receive said vapor stream and to expand it to said lower pressure, said first expansion means being further connected to said distillation column to supply said expanded vapor stream to said distillation column at a second mid-column feed position;

(7) third expansion means connected to said first separating means to receive at least a portion of said at least one liquid stream and to expand it to said lower pressure, said third expansion means being further connected to said distillation column to supply said expanded liquid stream to said distillation column at a third mid-column feed position;

(8) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from a region of said distillation column below said expanded vapor stream;

(9) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(10) second separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said second separating means being further connected to said distillation column to supply at least a portion of said condensed stream to said distillation column at a top feed position;

(11) said distillation column being further connected to said heat exchange means to direct at least a portion of said overhead vapor stream separated therein into heat exchange relation with said vapor distillation stream and heat said overhead vapor stream, thereby to supply at least a portion of the cooling of step (9), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(12) control means adapted to regulate the quantities and temperatures of said feed streams to said distillation column to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

32. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into an overhead vapor stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) dividing means prior to said first cooling means to divide said feed gas into first and second streams;

(2) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(3) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to said distillation column to supply said expanded cooled first stream to said distillation column at a first mid-column feed position;

(4) said first cooling means being connected to said first dividing means to receive said second stream, said first cooling means being adapted to cool said second stream under pressure sufficiently to partially condense it;

(5) first separating means connected to said first cooling means to receive said partially condensed second stream and to separate it into a vapor stream and at least one liquid stream;

(6) said first expansion means being connected to said first separating means to receive said vapor stream and to expand it to said lower pressure, said first expansion means being further connected to said distillation column to supply

said expanded vapor stream to said distillation column at a second mid-column feed position;

(7) third expansion means connected to said first separating means to receive at least a portion of said at least one liquid stream and to expand it to said lower pressure, said third expansion means being further connected to said distillation column to supply said expanded liquid stream to said distillation column at a third mid-column feed position;

(8) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from a region of said distillation column below said expanded vapor stream;

(9) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(10) second separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said second separating means being further connected to said distillation column to supply at least a portion of said condensed stream to said distillation column at a top feed position;

(11) combining means connected to said distillation column and said second separating means to receive said overhead vapor stream and said residual vapor stream and form a combined vapor stream;

(12) said combining means being further connected to said heat exchange means to direct at least a portion of said combined vapor stream into heat exchange relation with said vapor distillation stream and heat said combined vapor stream, thereby to supply at least a portion of the cooling of step (9), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(13) control means adapted to regulate the quantities and temperatures of said feed streams to said distillation column to maintain the overhead temperature of said distillation column at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

33. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into a vapor distillation stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) dividing means connected to said first cooling means to receive said cooled stream and to divide it into first and second streams;

(2) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(3) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to a contacting and separating means to supply said expanded cooled first stream to said contacting and separating means at a first mid-column feed position, said contacting and separating means being adapted to produce an overhead vapor stream and a bottom liquid stream;

(4) said first expansion means being connected to said dividing means to receive said second stream and to expand it to said lower pressure, said first expansion means being further connected to said contacting and separating means to supply said expanded second stream to said contacting and separating means at a second mid-column feed position;

(5) said distillation column being connected to said contacting and separating means to receive at least a portion of said bottom liquid stream;

(6) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from an upper region of said distillation column;

(7) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(8) separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said separating means being further connected to said contacting and separating means to supply at least a portion of said condensed stream to said contacting and separating means at a top feed position;

(9) said contacting and separating means being further connected to said heat exchange means to direct at least a portion of said overhead vapor stream separated therein into heat exchange relation with said vapor distillation stream and heat said overhead vapor stream, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(10) control means adapted to regulate the quantities and temperatures of said feed streams to said contacting and separating means to maintain the overhead temperature of said contacting and separating means at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

34. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into a vapor distillation stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) dividing means connected to said first cooling means to receive said cooled stream and to divide it into first and second streams;

(2) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(3) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to a contacting and separating means to supply said expanded cooled first stream to said contacting and

separating means at a first mid-column feed position, said contacting and separating means being adapted to produce an overhead vapor stream and a bottom liquid stream;

(4) said first expansion means being connected to said dividing means to receive said second stream and to expand it to said lower pressure, said first expansion means being further connected to said contacting and separating means to supply said expanded second stream to said contacting and separating means at a second mid-column feed position;

(5) said distillation column being connected to said contacting and separating means to receive at least a portion of said bottom liquid stream;

(6) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from an upper region of said distillation column;

(7) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(8) separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said separating means being further connected to said contacting and separating means to supply at least a portion of said condensed stream to said contacting and separating means at a top feed position;

(9) combining means connected to said contacting and separating means and said separating means to receive said overhead vapor stream and said residual vapor stream and form a combined vapor stream;

(10) said combining means being further connected to said heat exchange means to direct at least a portion of said combined vapor stream into heat exchange relation with said vapor distillation stream and heat said combined vapor stream, thereby to supply at least a portion of the cooling of step (7), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(11) control means adapted to regulate the quantities and temperatures of said feed streams to said contacting and separating means to maintain the overhead temperature of said contacting and separating means at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

35. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into a vapor distillation stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) dividing means prior to said first cooling means to divide said feed gas into first and second streams;

(2) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(3) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to a contacting and separating means to supply said expanded cooled first stream to said contacting and separating means at a first mid-column feed position, said contacting and separating means being adapted to produce an overhead vapor stream and a bottom liquid stream;

(4) said first cooling means being connected to said dividing means to receive said second stream and to cool it;

(5) said first expansion means being connected to said first cooling means to receive said cooled second stream and to expand it to said lower pressure, said first expansion means being further connected to said contacting and

separating means to supply said expanded cooled second stream to said contacting and separating means at a second mid-column feed position;

(6) said distillation column being connected to said contacting and separating means to receive at least a portion of said bottom liquid stream;

(7) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from an upper region of said distillation column;

(8) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(9) separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said separating means being further connected to said contacting and separating means to supply at least a portion of said condensed stream to said contacting and separating means at a top feed position;

(10) said contacting and separating means being further connected to said heat exchange means to direct at least a portion of said overhead vapor stream separated therein into heat exchange relation with said vapor distillation stream and heat said overhead vapor stream, thereby to supply at least a portion of the cooling of step (8), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(11) control means adapted to regulate the quantities and temperatures of said feed streams to said contacting and separating means to maintain the overhead temperature of said contacting and separating means at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

36. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into a vapor distillation stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) dividing means prior to said first cooling means to divide said feed gas into first and second streams;

(2) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(3) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to a contacting and separating means to supply said expanded cooled first stream to said contacting and separating means at a first mid-column feed position, said contacting and separating means being adapted to produce an overhead vapor stream and a bottom liquid stream;

(4) said first cooling means being connected to said dividing means to receive said second stream and to cool it;

(5) said first expansion means being connected to said first cooling means to receive said cooled second stream and to expand it to said lower pressure, said first expansion means being further connected to said contacting and separating means to supply said expanded cooled second stream to said contacting and separating means at a second mid-column feed position;

(6) said distillation column being connected to said contacting and separating means to receive at least a portion of said bottom liquid stream;

(7) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from an upper region of said distillation column;

(8) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(9) separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said separating means being further connected to said contacting and separating means to supply at least a portion of said condensed stream to said contacting and separating means at a top feed position;

(10) combining means connected to said contacting and separating means and said separating means to receive said overhead vapor stream and said residual vapor stream and form a combined vapor stream;

(11) said combining means being further connected to said heat exchange means to direct at least a portion of said combined vapor stream into heat exchange relation with said vapor distillation stream and heat said combined vapor stream, thereby to supply at least a portion of the cooling of step (8), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(12) control means adapted to regulate the quantities and temperatures of said feed streams to said contacting and separating means to maintain the overhead temperature of said contacting and separating means at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

37. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into a vapor distillation stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) said first cooling means being adapted to cool said feed gas under pressure sufficiently to partially condense it;

(2) first separating means connected to said first cooling means to receive said partially condensed feed and to separate it into a vapor stream and at least one liquid stream;

(3) dividing means connected to said first separating means to receive said vapor stream and to divide it into first and second streams;

(4) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(5) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to a contacting and separating means to supply said expanded cooled first stream to said contacting and separating means at a first mid-column feed position, said contacting and separating means being adapted to produce an overhead vapor stream and a bottom liquid stream;

(6) said first expansion means being connected to said dividing means to receive said second stream and to expand it to said lower pressure, said first expansion means being further connected to said contacting and separating means to supply said expanded second stream to said contacting and separating means at a second mid-column feed position;

(7) third expansion means connected to said first separating means to receive at least a portion of said at least one liquid stream and to expand it to said lower pressure, said third expansion means being further connected to said contacting and separating means to supply said expanded liquid stream to said contacting and separating means at a third mid-column feed position;

(8) said distillation column being connected to said contacting and separating means to receive at least a portion of said bottom liquid stream;

(9) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from an upper region of said distillation column;

(10) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(11) second separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said second separating means being further connected to said contacting and separating means to supply at least a portion of said condensed stream to said contacting and separating means at a top feed position;

(12) said contacting and separating means being further connected to said heat exchange means to direct at least a portion of said overhead vapor stream separated therein into heat exchange relation with said vapor distillation stream and heat said overhead vapor stream, thereby to supply at least a portion of the cooling of step (10), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(13) control means adapted to regulate the quantities and temperatures of said feed streams to said contacting and separating means to maintain the overhead temperature of said contacting and separating means at a temperature whereby

the major portions of the components in said relatively less volatile fraction are recovered.

38. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into a vapor distillation stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) said first cooling means being adapted to cool said feed gas under pressure sufficiently to partially condense it;

(2) first separating means connected to said first cooling means to receive said partially condensed feed and to separate it into a vapor stream and at least one liquid stream;

(3) dividing means connected to said first separating means to receive said vapor stream and to divide it into first and second streams;

(4) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(5) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to a contacting and separating means to supply said expanded cooled first stream to said contacting and separating means at a first mid-column feed position, said contacting and separating means being adapted to produce an overhead vapor stream and a bottom liquid stream;

(6) said first expansion means being connected to said dividing means to receive said second stream and to expand it to said lower pressure, said first expansion means being further connected to said contacting and separating means to supply said expanded second stream to said contacting and separating means at a second mid-column feed position;

(7) third expansion means connected to said first separating means to receive at least a portion of said at least one liquid stream and to expand it to said lower pressure, said third expansion means being further connected to said contacting and separating means to supply said expanded liquid stream to said contacting and separating means at a third mid-column feed position;

(8) said distillation column being connected to said contacting and separating means to receive at least a portion of said bottom liquid stream;

(9) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from an upper region of said distillation column;

(10) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(11) second separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said second separating means being further connected to said contacting and separating means to supply at least a portion of said condensed stream to said contacting and separating means at a top feed position;

(12) combining means connected to said contacting and separating means and said second separating means to receive said overhead vapor stream and said residual vapor stream and form a combined vapor stream;

(13) said combining means being further connected to said heat exchange means to direct at least a portion of said combined vapor stream into heat exchange relation with said vapor distillation stream and heat said combined vapor stream, thereby to supply at least a portion of the cooling of step (10), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(14) control means adapted to regulate the quantities and temperatures of said feed streams to said contacting and separating means to maintain the overhead temperature of said contacting and separating means at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

39. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into a vapor distillation stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) said first cooling means being adapted to cool said feed gas under pressure sufficiently to partially condense it;

(2) first separating means connected to said first cooling means to receive said partially condensed feed and to separate it into a vapor stream and at least one liquid stream;

(3) dividing means connected to said first separating means to receive said vapor stream and to divide it into first and second streams;

(4) combining means connected to said dividing means and said first separating means to receive said first stream and at least a portion of said at least one liquid stream and form a combined stream;

(5) second cooling means connected to said combining means to receive said combined stream and to cool it sufficiently to substantially condense it;

(6) second expansion means connected to said second cooling means to receive said substantially condensed combined stream and to expand it to said lower pressure, said second expansion means being further connected to a contacting and separating means to supply said expanded cooled combined stream to said contacting and separating means at a first mid-column feed position, said contacting and separating means being adapted to produce an overhead vapor stream and a bottom liquid stream;

(7) said first expansion means being connected to said dividing means to receive said second stream and to expand it to said lower pressure, said first expansion means being further connected to said contacting and separating means to supply said expanded second stream to said contacting and separating means at a second mid-column feed position;

(8) third expansion means connected to said first separating means to receive any remaining portion of said at least one liquid stream and to expand it to said lower pressure, said third expansion means being further connected to said contacting and separating means to supply said expanded liquid stream to said contacting and separating means at a third mid-column feed position;

(9) said distillation column being connected to said contacting and separating means to receive at least a portion of said bottom liquid stream;

(10) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from an upper region of said distillation column;

(11) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(12) second separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said second separating means being further connected to said contacting and separating means to supply at least a portion of said condensed stream to said contacting and separating means at a top feed position;

(13) said contacting and separating means being further connected to said heat exchange means to direct at least a portion of said overhead vapor stream separated therein into heat exchange relation with said vapor distillation stream

and heat said overhead vapor stream, thereby to supply at least a portion of the cooling of step (11), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(14) control means adapted to regulate the quantities and temperatures of said feed streams to said contacting and separating means to maintain the overhead temperature of said contacting and separating means at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

40. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into a vapor distillation stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) said first cooling means being adapted to cool said feed gas under pressure sufficiently to partially condense it;

(2) first separating means connected to said first cooling means to receive said partially condensed feed and to separate it into a vapor stream and at least one liquid stream;

(3) dividing means connected to said first separating means to receive said vapor stream and to divide it into first and second streams;

(4) first combining means connected to said dividing means and said first separating means to receive said first stream and at least a portion of said at least one liquid stream and form a combined stream;

(5) second cooling means connected to said first combining means to receive said combined stream and to cool it sufficiently to substantially condense it;

(6) second expansion means connected to said second cooling means to receive said substantially condensed combined stream and to expand it to said lower pressure, said second expansion means being further connected to a contacting and separating means to supply said expanded cooled combined stream to said contacting and separating means at a first mid-column feed position, said contacting and separating means being adapted to produce an overhead vapor stream and a bottom liquid stream;

(7) said first expansion means being connected to said dividing means to receive said second stream and to expand it to said lower pressure, said first expansion means being further connected to said contacting and separating means to

supply said expanded second stream to said contacting and separating means at a second mid-column feed position;

(8) third expansion means connected to said first separating means to receive any remaining portion of said at least one liquid stream and to expand it to said lower pressure, said third expansion means being further connected to said contacting and separating means to supply said expanded liquid stream to said contacting and separating means at a third mid-column feed position;

(9) said distillation column being connected to said contacting and separating means to receive at least a portion of said bottom liquid stream;

(10) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from an upper region of said distillation column;

(11) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(12) second separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said second separating means being further connected to said contacting and separating means to supply at least a portion of said condensed stream to said contacting and separating means at a top feed position;

(13) second combining means connected to said contacting and separating means and said second separating means to receive said overhead vapor stream and said residual vapor stream and form a combined vapor stream;

(14) said second combining means being further connected to said heat exchange means to direct at least a portion of said combined vapor stream into heat exchange relation with said vapor distillation stream and heat said combined vapor stream, thereby to supply at least a portion of the cooling of step (11), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(15) control means adapted to regulate the quantities and temperatures of said feed streams to said contacting and separating means to maintain the overhead temperature of said contacting and separating means at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

41. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into a vapor distillation stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) dividing means prior to said first cooling means to divide said feed gas into first and second streams;

(2) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(3) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to a contacting and separating means to supply said expanded cooled first stream to said contacting and separating means at a first mid-column feed position, said contacting and separating means being adapted to produce an overhead vapor stream and a bottom liquid stream;

(4) said first cooling means being connected to said first dividing means to receive said second stream, said first cooling means being adapted to cool said second stream under pressure sufficiently to partially condense it;

(5) first separating means connected to said first cooling means to receive said partially condensed second stream and to separate it into a vapor stream and at least one liquid stream;

(6) said first expansion means being connected to said first separating means to receive said vapor stream and to expand it to said lower pressure, said first expansion means being further connected to said contacting and separating means to supply said expanded vapor stream to said contacting and separating means at a second mid-column feed position;

(7) third expansion means connected to said first separating means to receive at least a portion of said at least one liquid stream and to expand it to said lower pressure, said third expansion means being further connected to said contacting and separating means to supply said expanded liquid stream to said contacting and separating means at a third mid-column feed position;

(8) said distillation column being connected to said contacting and separating means to receive at least a portion of said bottom liquid stream;

(9) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from an upper region of said distillation column;

(10) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(11) second separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said second separating means being further connected to said contacting and separating means to supply at least a portion of said condensed stream to said contacting and separating means at a top feed position;

(12) said contacting and separating means being further connected to said heat exchange means to direct at least a portion of said overhead vapor stream separated therein into heat exchange relation with said vapor distillation stream and heat said overhead vapor stream, thereby to supply at least a portion of the cooling of step (10), and thereafter discharging at least a portion of said heated overhead vapor stream as said volatile residue gas fraction; and

(13) control means adapted to regulate the quantities and temperatures of said feed streams to said contacting and separating means to maintain the overhead temperature of said contacting and separating means at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

42. In an apparatus for the separation of a gas stream containing methane, C_2 components, C_3 components, and heavier hydrocarbon components into a volatile residue gas fraction and a relatively less volatile fraction containing a major portion of said C_2 components, C_3 components, and heavier hydrocarbon components or said C_3 components and heavier hydrocarbon components, in said apparatus there being

(a) a first cooling means to cool said gas under pressure connected to provide a cooled stream under pressure;

(b) a first expansion means connected to receive at least a portion of said cooled stream under pressure and to expand it to a lower pressure, whereby said stream is further cooled; and

(c) a distillation column connected to receive said further cooled stream, said distillation column being adapted to separate said further cooled stream into a vapor distillation stream and said relatively less volatile fraction;

the improvement wherein said apparatus includes

(1) dividing means prior to said first cooling means to divide said feed gas into first and second streams;

(2) second cooling means connected to said dividing means to receive said first stream and to cool it sufficiently to substantially condense it;

(3) second expansion means connected to said second cooling means to receive said substantially condensed first stream and to expand it to said lower pressure, said second expansion means being further connected to a contacting and separating means to supply said expanded cooled first stream to said contacting and separating means at a first mid-column feed position, said contacting and separating means being adapted to produce an overhead vapor stream and a bottom liquid stream;

(4) said first cooling means being connected to said first dividing means to receive said second stream, said first cooling means being adapted to cool said second stream under pressure sufficiently to partially condense it;

(5) first separating means connected to said first cooling means to receive said partially condensed second stream and to separate it into a vapor stream and at least one liquid stream;

(6) said first expansion means being connected to said first separating means to receive said vapor stream and to expand it to said lower pressure, said first expansion means being further connected to said contacting and separating means to supply said expanded vapor stream to said contacting and separating means at a second mid-column feed position;

(7) third expansion means connected to said first separating means to receive at least a portion of said at least one liquid stream and to expand it to said lower pressure, said third expansion means being further connected to said contacting and separating means to supply said expanded liquid stream to said contacting and separating means at a third mid-column feed position;

(8) said distillation column being connected to said contacting and separating means to receive at least a portion of said bottom liquid stream;

(9) vapor withdrawing means connected to said distillation column to receive a vapor distillation stream from an upper region of said distillation column;

(10) heat exchange means connected to said vapor withdrawing means to receive said vapor distillation stream and cool it sufficiently to condense at least a part of it;

(11) second separating means connected to said heat exchange means to receive said partially condensed distillation stream and separate it, thereby forming a residual vapor stream and a condensed stream, said second separating means being further connected to said contacting and separating means to supply at least a portion of said condensed stream to said contacting and separating means at a top feed position;

(12) combining means connected to said contacting and separating means and said second separating means to receive said overhead vapor stream and said residual vapor stream and form a combined vapor stream;

(13) said combining means being further connected to said heat exchange means to direct at least a portion of said combined vapor stream into heat exchange relation with said vapor distillation stream and heat said combined vapor stream, thereby to supply at least a portion of the cooling of step (10), and thereafter discharging at least a portion of said heated combined vapor stream as said volatile residue gas fraction; and

(14) control means adapted to regulate the quantities and temperatures of said feed streams to said contacting and separating means to maintain the overhead temperature of said contacting and separating means at a temperature whereby the major portions of the components in said relatively less volatile fraction are recovered.

43. The improvement according to claim 23, 24, 25, or 26 wherein

(1) a second dividing means is connected to said separating means to divide said condensed stream into at least a first portion and a second portion;

(2) said second dividing means being further connected to said distillation column to supply said first portion to said distillation column at a top feed position; and

(3) said second dividing means being further connected to said distillation column to supply said second portion to said distillation column at a feed position in substantially the same region wherein said vapor distillation stream is withdrawn.

44. The improvement according to claim 27, 28, 29, 30, 31, or 32 wherein

(1) a second dividing means is connected to said second separating means to divide said condensed stream into at least a first portion and a second portion;

(2) said second dividing means being further connected to said distillation column to supply said first portion to said distillation column at a top feed position; and

(3) said second dividing means being further connected to said distillation column to supply said second portion to said distillation column at a feed position in substantially the same region wherein said vapor distillation stream is withdrawn.

45. The improvement according to claim 33, 34, 35, or 36 wherein

(1) a second dividing means is connected to said separating means to divide said condensed stream into at least a first portion and a second portion;

(2) said second dividing means being further connected to said contacting and separating means to supply said first portion to said contacting and separating means at a top feed position; and

(3) said second dividing means being further connected to said distillation column to supply said second portion to said distillation column at a top feed position.

46. The improvement according to claim 37, 38, 39, 40, 41, or 42 wherein

(1) a second dividing means is connected to said second separating means to divide said condensed stream into at least a first portion and a second portion;

(2) said second dividing means being further connected to said contacting and separating means to supply said first portion to said contacting and separating means at a top feed position; and

(3) said second dividing means being further connected to said distillation column to supply said second portion to said distillation column at a top feed position.

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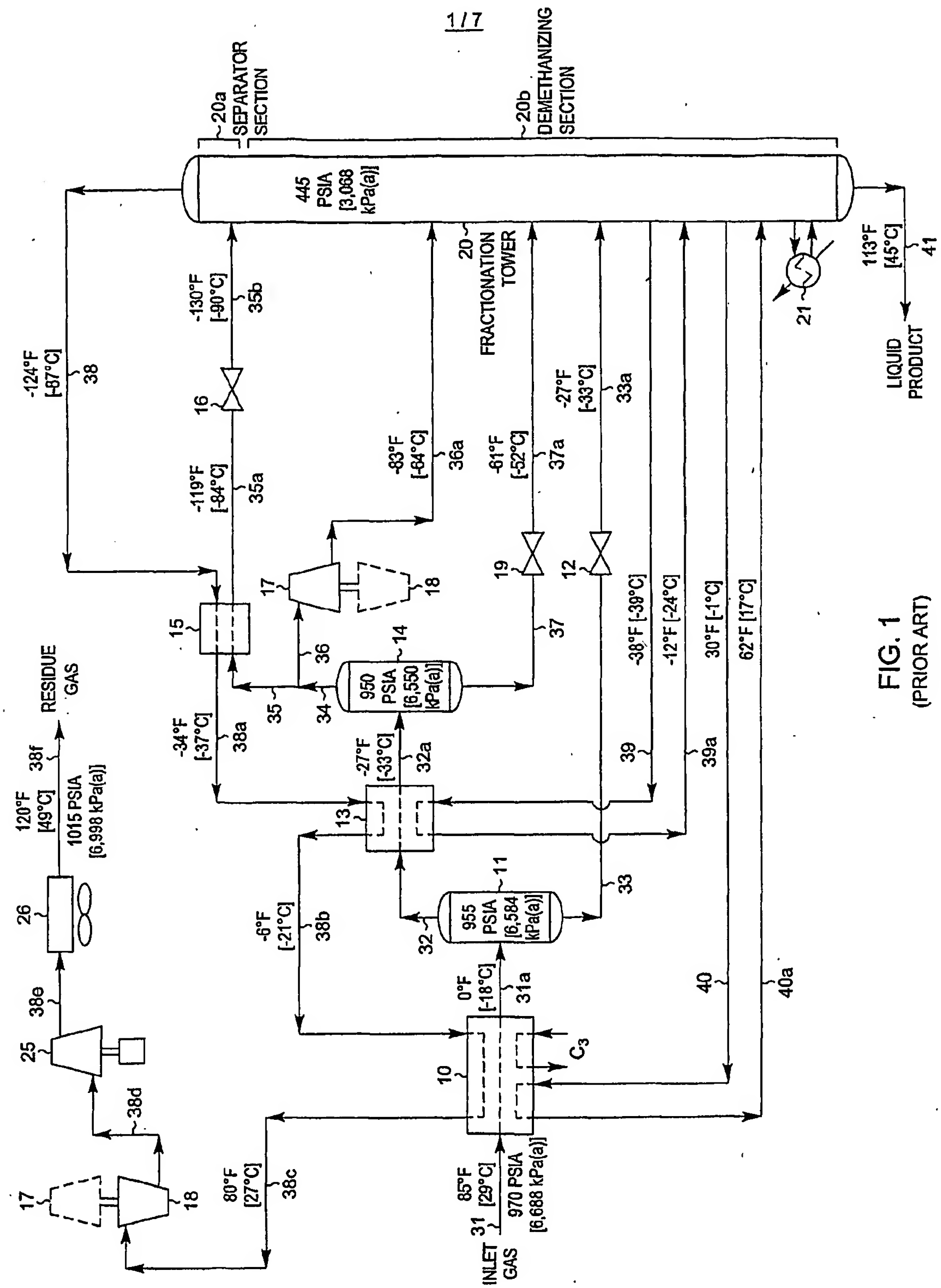

FIG. 1
(PRIOR ART)

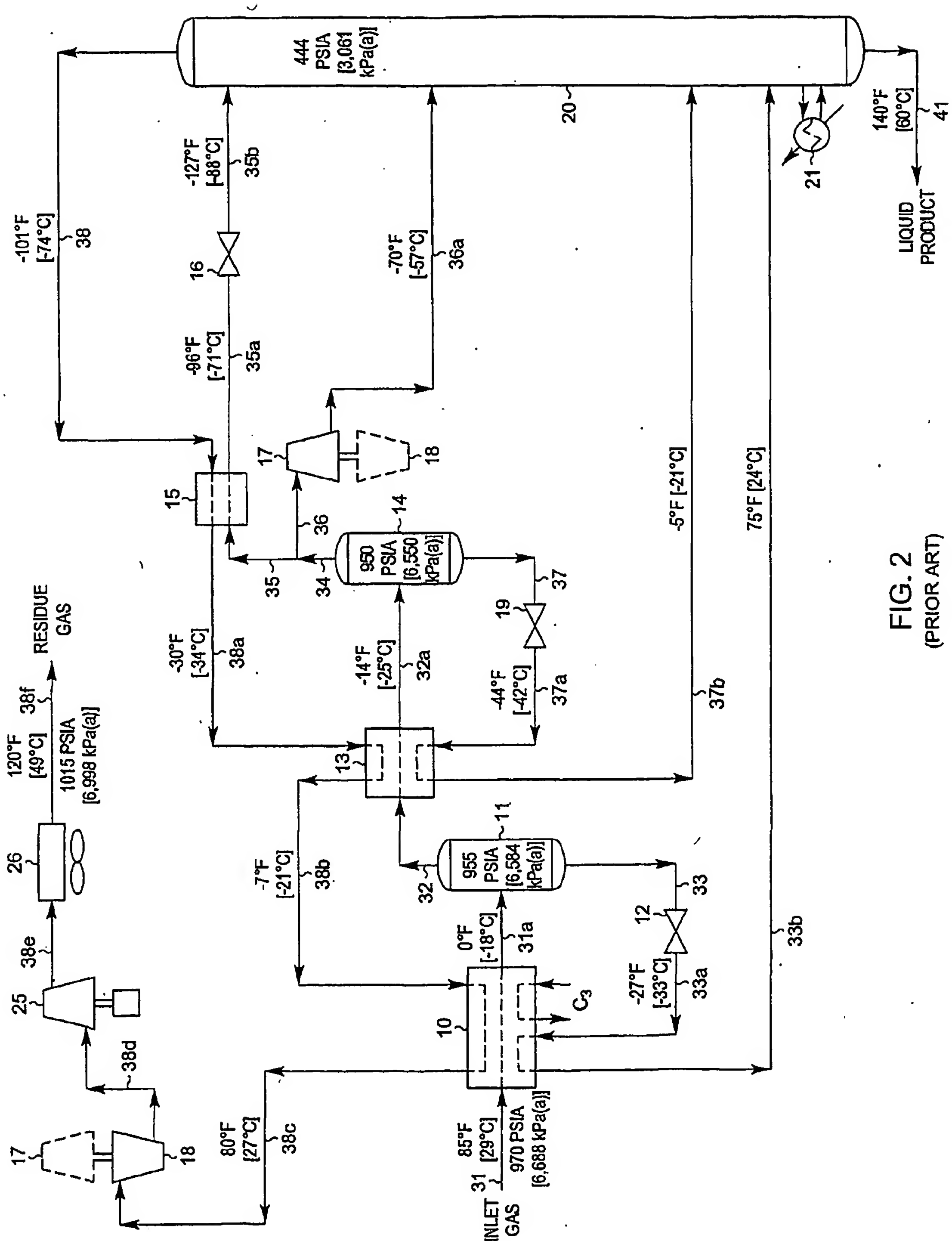

FIG. 2
(PRIOR ART)

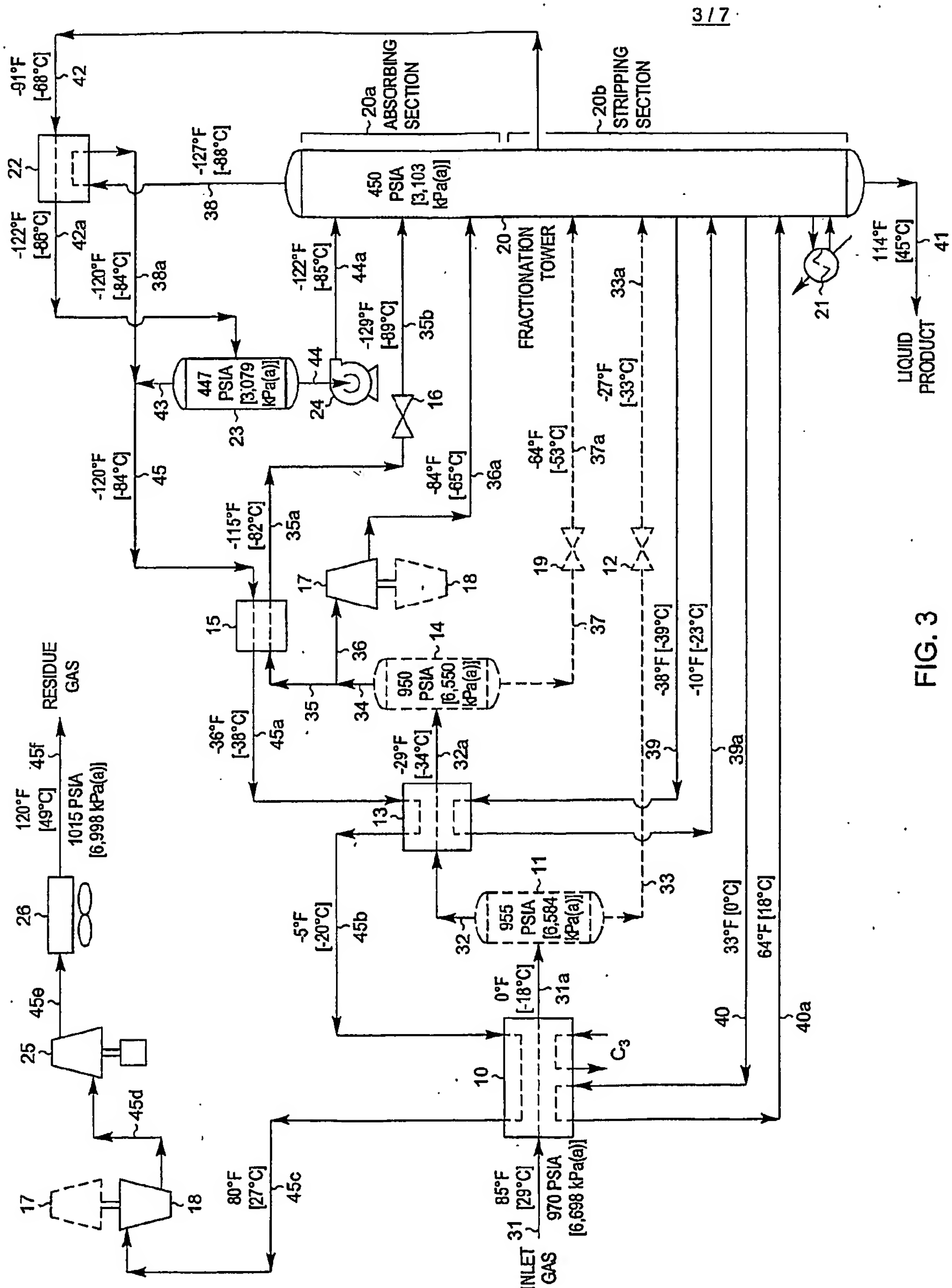
INLET GAS
31
85°F [29°C]
970 PSIA [6,698 kPa(a)]
10
C3
0°F [-18°C]
31a
955 PSIA [6,584 kPa(a)]
11
32
33
13
-29°F [-34°C]
32a
950 PSIA [6,550 kPa(a)]
14
34
35
36
37
17
18
15
-115°F [-82°C]
35a
16
-129°F [-89°C]
35b
-84°F [-65°C]
36a
19
-84°F [-53°C]
37a
12
-27°F [-33°C]
33a
-38°F [-39°C]
39
-10°F [-23°C]
39a
33°F [0°C]
40
64°F [18°C]
40a
20
FRACTIONATION TOWER
450 PSIA [3,103 kPa(a)]
20a ABSORBING SECTION
20b STRIPPING SECTION
21
114°F [45°C]
41
LIQUID PRODUCT
-127°F [-88°C]
38
38a
22
-91°F [-68°C]
42
-122°F [-86°C]
42a
-120°F [-84°C]
447 PSIA [3,079 kPa(a)]
23
43
44
24
-122°F [-85°C]
44a
-120°F [-84°C]
45
-36°F [-38°C]
45a
-5°F [-20°C]
45b
80°F [27°C]
45c
45d
25
45e
26
120°F [49°C]
1015 PSIA [6,998 kPa(a)]
45f
RESIDUE GAS

FIG. 3

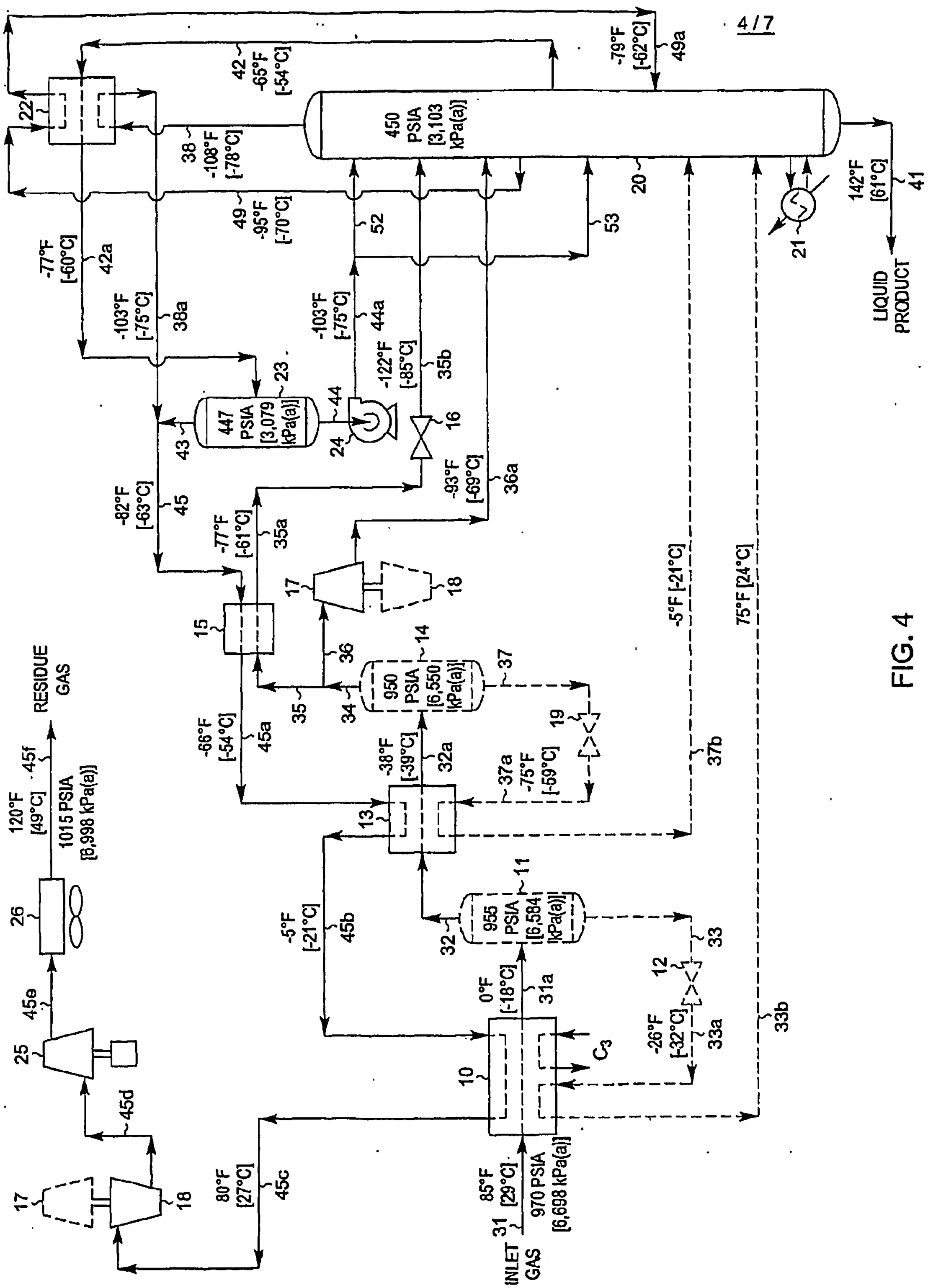
INLET GAS
85°F [29°C]
970 PSIA [6,698 kPa(a)]
0°F [-18°C]
955 PSIA [6,584 kPa(a)]
-26°F [-32°C]
C3
-38°F [-39°C]
-75°F [-59°C]
950 PSIA [6,550 kPa(a)]
-66°F [-54°C]
-5°F [-21°C]
80°F [27°C]
-77°F [-61°C]
-93°F [-69°C]
-82°F [-63°C]
447 PSIA [3,079 kPa(a)]
-122°F [-85°C]
-103°F [-75°C]
-77°F [-60°C]
-95°F [-70°C]
-108°F [-78°C]
-65°F [-54°C]
-79°F [-62°C]
450 PSIA [3,103 kPa(a)]
142°F [61°C]
LIQUID PRODUCT
-5°F [-21°C]
75°F [24°C]
RESIDUE GAS
120°F [49°C]
1015 PSIA [6,998 kPa(a)]

FIG. 4

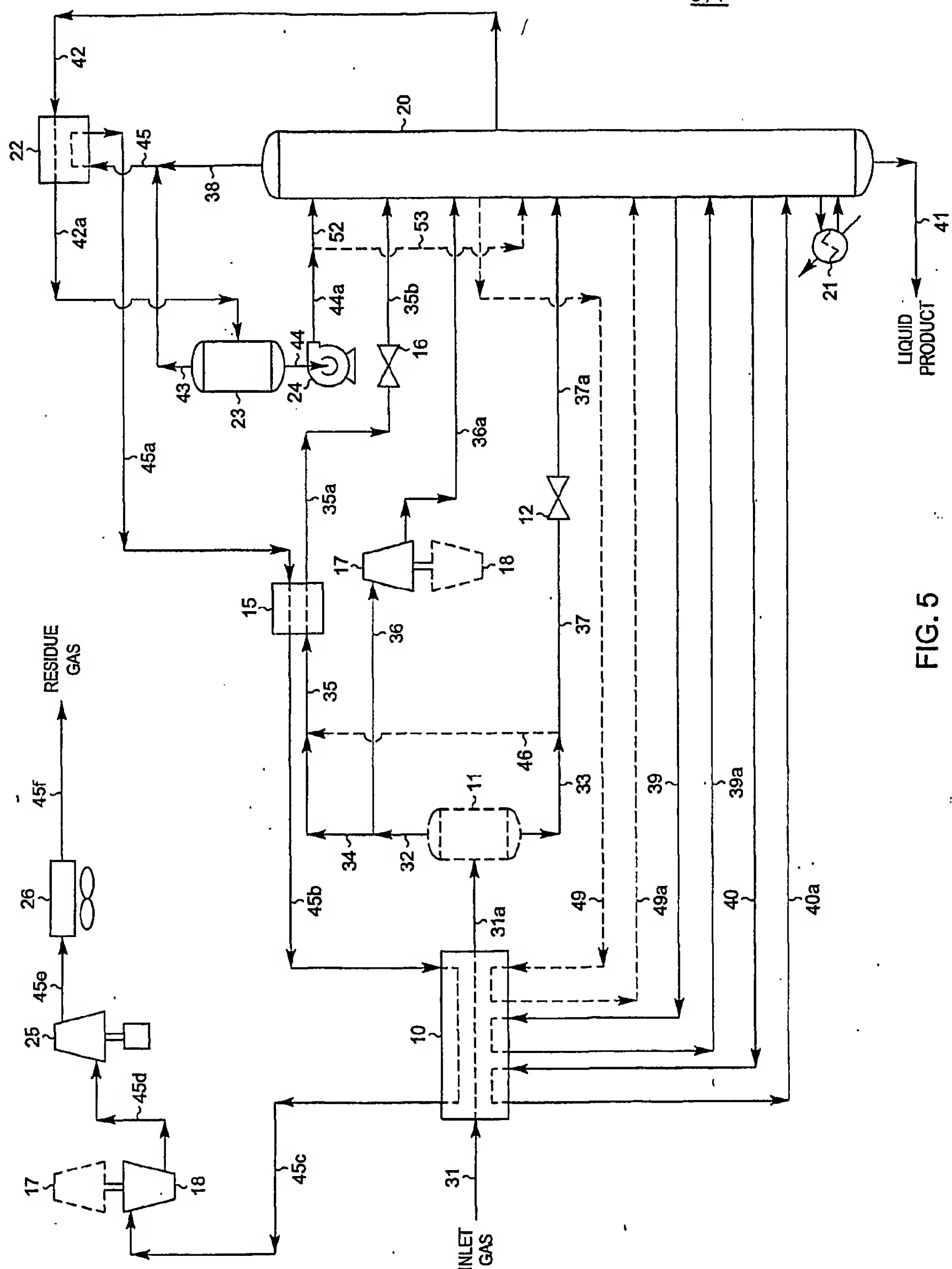
RESIDUE GAS
INLET GAS
LIQUID PRODUCT
10
11
12
15
16
17
18
20
21
22
23
24
25
26
31
31a
32
33
34
35
35a
35b
36
36a
37
37a
38
39
39a
40
40a
41
42
42a
43
44
44a
45
45a
45b
45c
45d
45e
45f
46
49
49a
52
53

FIG. 5

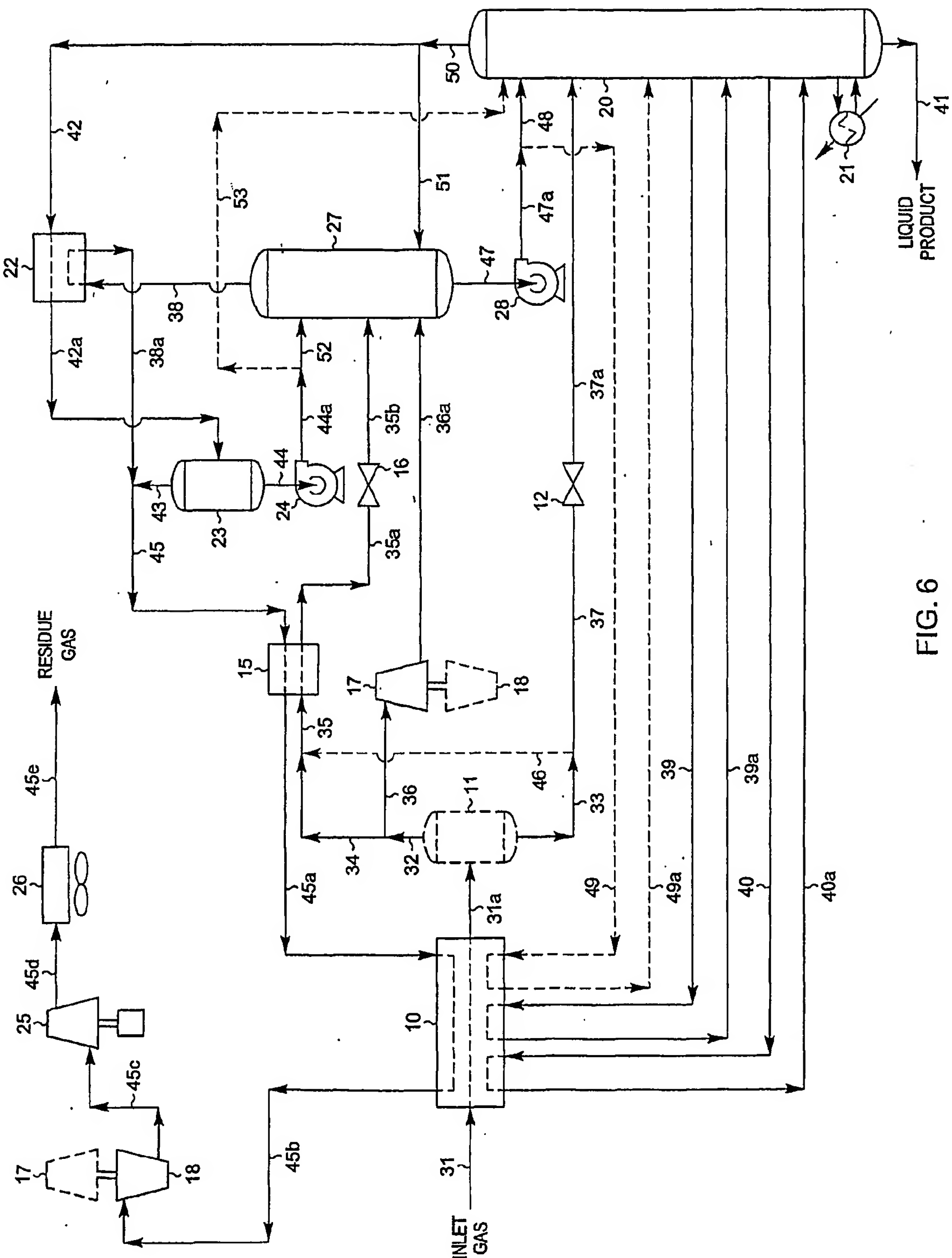

FIG. 6

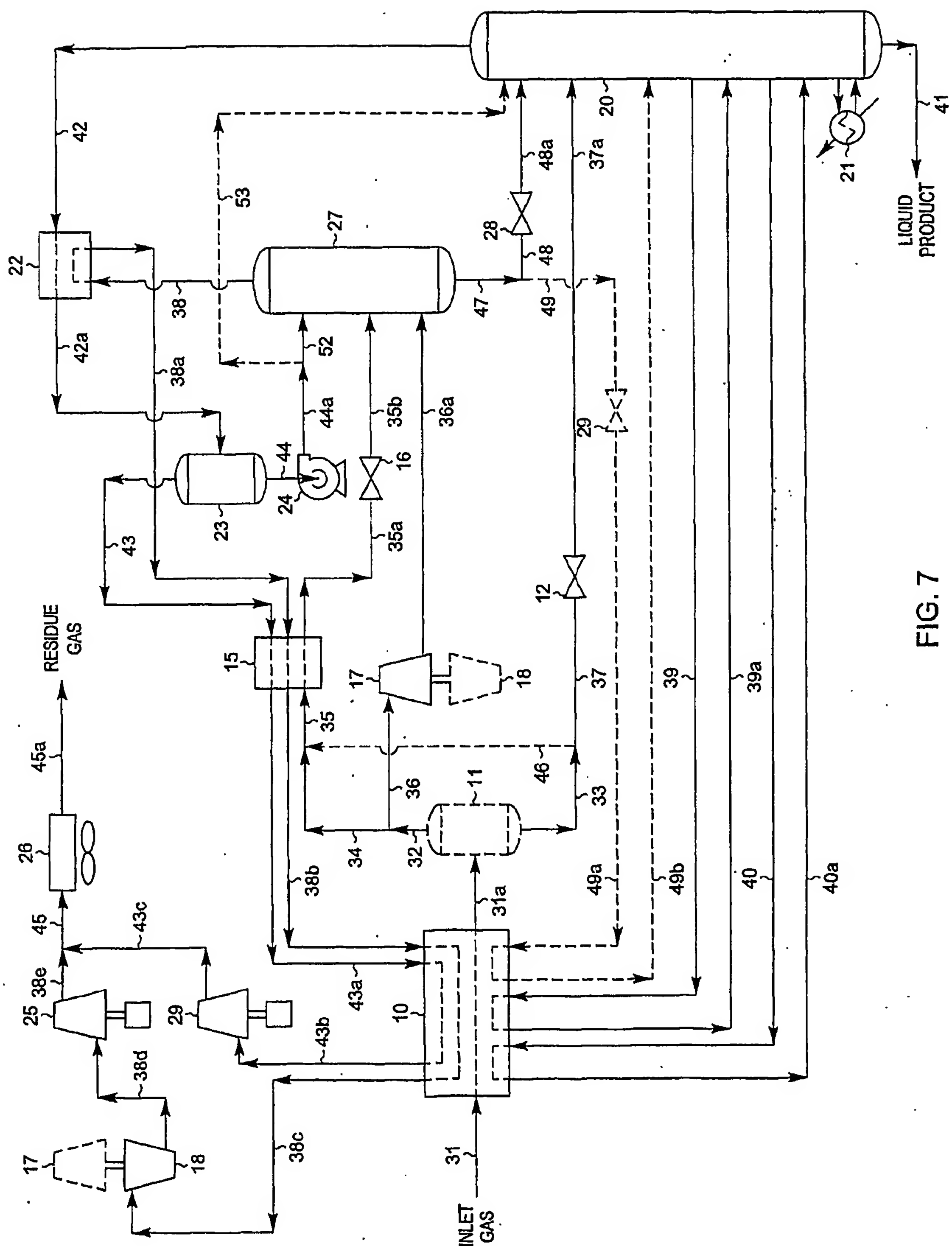

FIG. 7